Abschlussbericht zum Förderungsantrag

Antragstitel: International Conference on Environmental Informatics

Aktenzeichen: 30241

Projektbeginn: 17.07.2012

Projektende: 30.06.2013

Bewilligungsempfänger:
Otto-von-Guericke-Universität Magdeburg
Institut für Technische und Betriebliche Informationssysteme
Arbeitsgruppe Wirtschaftsinformatik
– Managementinformationssysteme -
Universitätsplatz 2
39106 Magdeburg

Kooperationspartner:
Deutsches Umweltbundesamt
Informationssysteme Chemikaliensicherheit
Wörlitzer Platz 1
06844 Dessau-Roßlau

Projektleitung: Prof. Dr. Hans-Knud Arndt

06/02

Projektkennblatt
der
Deutschen Bundesstiftung Umwelt

Az	30241	Referat	42	Fördersumme	28.945 Euro

Antragstitel	**International Conference on Informatics for Environmental Protection**
Stichworte	Informatik, Umwelt, Gesundheit

Laufzeit	Projektbeginn	Projektende	Projektphase(n)
11 Monate	**17.07.2011**	**30.06.2013**	**1**

Bewilligungsempfänger	Otto-von-Guericke-Universität Magdeburg Intitut für Technische und Betriebliche Informationssysteme Arbeitsgruppe Wirtschaftsinformatik - Managementinformationssysteme - Universitätsplatz 2 39106 Magdeburg	Tel 0391/67-58542 Fax 0391/67-18050 Projektleitung Prof. Dr. Hans-Knud Arndt Bearbeiter Prof. Dr. Hans-Knud Arndt
Kooperationspartner	Deutsches Umweltbundesamt Informationssysteme Chemikaliensicherheit Wörlitzer Platz 1 06844 Dessau-Roßlau	

Zielsetzung und Anlass des Vorhabens

Einbringen wissenschaftlich gesicherten Informationen im Bereich gesundheitsrelevanter Umweltinformation unter Nutzung modernster Informatikanwendungen in die Europäische Umweltkommunikation.

Darstellung der Arbeitsschritte und der angewandten Methoden

Gesundheitsrelevante Umweltinformation ist ein Teilgebiet der Umweltforschung. Sowohl Umwelt- als auch Gesundheitsberichterstattung beinhalten nur vereinzelt interdisziplinäre Bezüge. Informationen aus dem Fachbereich Umwelt und Gesundheit beziehen zwar Ergebnisse der Umweltforschung mit Bezug zur Früherkennung, Krankheitsentstehung und Prävention ein. Sie beinhalten jedoch viel zu wenig den Aspekt der zielgruppenorientierten Kommunikation und Bereitstellung. Die Informationsaufbereitung von gesundheitsbezogenen Umweltdaten und Informationen kann gerade heute im Zeitalter moderner Informations- und Kommunikationstechnologien verständlicher, öffentlichkeitwirksamer und für weitere Forschungsdisziplinen stattfinden. Dies bedeutet auch eine Steigerung des Mehrwerts gesundheitsrelevanter Umweltinformationen.

Im Projekt

- wurde eine Übersicht über den derzeitigen Stand der Umwelt- und Gesundheit-Projekte aus wissenschaftlicher politischer und verwaltungsbezogenen Perspektive gegeben.
- wurden EnviroInfo-Sitzungen zum Thema Umwelt und Gesundheit organisiert.
- wurden Informationen zum Thema Umwelt und Gesundheit aus einer nationalen und Europäischen Perspektive betrachtet.
- wurde genau an der Schnittstelle zur medizinischen, klinischen und epidemiologischen Forschung angesetzt, wobei deutschsprachigen Umwelt- und Gesundheits-Projekte und das Thema Chemikaliensicherheit im Fokus stehen.
- wurden vorliegende Teilergebnisse mit Experten im Rahmen einer Podiumsdiskussion diskutiert.

Ergebnisse und Diskussion

Mit der Fokussierung der EnviroInfo 2012 auf das Thema Umwelt und Gesundheit konnte die Lücke der Informationsvermittlung weiter geschlossen werden. Im Rahmen des Workshops „Kommunikation umweltbezogener Gesundheitsvorsorge“ wurden acht begutachtete Beiträge ausgewählt und präsentiert. Als Ergebnis dieses Workshops konnte die Bedeutung der Informatik für das Aufzeigen von umweltbeeinflussten Gesundheitseffekten aufgezeigt werden. Dieser Zusammenhang konnte auch durch ein Metamodell beschrieben werden, welches die Unterstützung von Umweltinformationen für die Betrachtung von umwelt- und gesundheitsbezogenen Fragestellungen unterstreicht.
Über den Workshop „Kommunikation umweltbezogener Gesundheitsvorsorge“ hinaus wurde Erkenntnisse gesundheitsrelevanter Umweltinformation im Rahmen der EinviroInfo 2012 vor allem im Hinblick auf Chemikaliensicherheit gewonnen.
Insgesamt wurden auf der EnviroInfo 2012 im Bereich Umwelt und Gesundheit eine Vielzahl wissenschaftlicher Diskussionen geführt und in Form von Beiträgen veröffentlicht.

Öffentlichkeitsarbeit und Präsentation

Mit der Ausgestaltung der 26. EnviroInfo im Umweltbundesamt Dessau unter der Federführung des Fachausschusses Umweltinformatik zeichnet sich eine Wissenschaftlergruppe verantwortlich, die seit mehr als 25 Jahren Erfahrungen in der Ausgestaltung derartiger international anerkannter und sicht-barer Veranstaltungen hat. Der Fachausschuss Umweltinformatik ist Teil der Gesellschaft für Informatik, die eingebettet ist in einen gesellschaftlichen Kontext der Lebenswissenschaften. Die Ausgestaltung der Konferenzen umfasst neben der Organisation von spezifischen Workshops auch die Verleihung des „Environmental Informatics Prize for Students“, welcher ein öffentlichkeitswirksamer Anreiz für Nachwuchswissenschaftler ist, Kreativität und Innovation in die Umsetzung von Umweltthemen unter Nutzung modernster IT-Kommunikationswerkzeuge und -instrumente einzubringen.
Die Beiträge zur Tagung EnviroInfo 2012 sind in Druckform digital frei zugänglich über das Portal: ICT-ENSURE.

Fazit

Im Rahmen der Konferenz EnviroInfo 2012, die vom 29.-31.08.2012 im Umweltbundesamt in Dessau stattgefunden hat, konnte eine erste interdisziplinäre Aufbereitung des Themas „Kommunikation umweltbezogener Gesundheitsvorsorge“ vorgenommen werden.
Durch die Anwesenheit von Experten aus Umweltforschung und Informatik wurde das übergreifende Ziel, umweltrelevante Gesundheitsinformationen zielgruppenorientierter zu kommunizieren und eine zukunftsorientierte Perspektive zu entwickeln, erreicht. Besondere Beachtung fanden dabei auch die Europäischen Programme in INSPIRE (Annex III „Health“) und die Entwicklungen zu einem „Shared Environmental Information Space“ (SEIS).

Inhalt

1. Zielsetzung und Anlass des Vorhabens 1

2. Darstellung der Arbeitsschritte und der angewandten Methoden 2

3. Ergebnisse und Diskussion 4

4. Öffentlichkeitsarbeit und Präsentation 7

5. Fazit 8

A. Anhang 9

A.1. Sex Odds in Important Indicator for Changes in Environmental Health (Voigt K./Scherb, H./Kusmierz, R.) 9

A.2. Analysing Health Risks from Air Pollution Effects in Saxony, Germany (Richter, S./Wiemann, S./Karrasch, P./Kadner, D./Brauner, J./Siegert, J./Rossmann, J./Elsner, B./Arloth, J.) 15

A.3. Avian Influenza: Risks, Impacts and Policy Implications (Armbruster. W.) 23

A.4. Environmental and Sustainability Indicators: Case Study for Agriculture and Food Processing Sector (Hřebíček, J./Hodinka, M./Motyčka, A./Popelka, O./Trenz, O.) 31

A.5. Annotation of Environmental and Epidemiological Systems: TaToo case study (Kubásek, M./Hřebíček, J./Kalina, J.) 43

A.6. Application of Sensor Web Technology for Analysing Correlations between Health and Environmental Data (Jirka, S./Brauner, J./Bröring, A./Kunz, S./Simonis, I./Watson, K.) 53

A.7. ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb (Davila, S./Bešlić, I./Pečar-Ilić , J./Šega, K.) 63

A.8. Interlink between Environment and Health Information (Pillmann, W.) 73

A.9. Chemicals in our life: Communication Strategies for Chemical Information under REACH (Knetsch, G) 81

A.10. Modular Information System on Chemicals – From Concept to Reality (Menger, M./Bandholtz, T./Ackermann, P./Jaspert, R.) 89

A.11. BIG Kosmos: a cosmos of chemical information (Kuyken, W.) 99

A.12. Dioxine Database – An Approach of Congener-Specific Data Analysis (Gärtner, P./Knetsch, G./Raab, G./Nouhuys, J. v.) 103

1. Zielsetzung und Anlass des Vorhabens

Informatik bzw. Informations- und Kommunikationstechnik (IKT) dringen in zunehmende Maße in immer mehr Lebensbereiche vor. Um die IKT auch im Sinne einer Gesundheitsvorsorge nutzen zu können, ist die Betrachtung der Umwelt von entscheidender Bedeutung. Damit wird nicht ein primär IKT-bezogener Zugang in Verbindung mit einem Anwendungsgebiet, wie es z.B. in der Medizininformatik der Fall ist, als Herangehensweise gewählt, sondern die Betrachtung von Umweltfragen wird als fehlendes Bindeglied zwischen IKT und Gesundheitsvorsorge identifiziert.

Gesundheitsrelevante Umweltinformation ist ein Teilgebiet der Umweltforschung. Sowohl Umwelt- als auch Gesundheitsberichterstattung beinhalten nur vereinzelt interdisziplinäre Bezüge. Informationen aus dem Fachbereich Umwelt und Gesundheit beziehen zwar Ergebnisse der Umweltforschung mit Bezug zur Früherkennung, Krankheitsentstehung und Prävention ein. Sie beinhalten jedoch viel zu wenig den Aspekt der zielgruppenorientierten Kommunikation und Bereitstellung.

In den 1980er Jahren formierte sich eine Gruppe von Forscherinnen und Forschern, die sich mit der Gewinnung und Verbreitung von Umweltinformation mit Informations- und Kommunikationstechnologien beschäftigten. Beginnend mit dem Symposium „Informatik für den Umweltschutz“ (1986) etablierten sich der Fachausschuss Umweltinformatik in der Gesellschaft für Informatik (GI, Bonn), der in seinen jährlichen Konferenzen EnviroInfo (2012)[1] Themen zu „Informatik im Umweltschutz, nachhaltige Entwicklung und Risikomanagement“ kommuniziert.

In der Europäischen Kommission ist man bemüht, eine Verbindung zwischen den Inseln von Umweltinformation in einem „Shared Environmental Information System“ (SEIS[2]) zu schaffen. Die Umweltämter der EU verfügen umfassend über Bausteine zu einem solchen System.

Ziel des Vorhabens liegt in einer Bestandsaufnahme, der Informationsaufbereitung von gesundheitsbezogenen Umweltdaten und Informationen, denn gerade heute im Zeitalter moderner IKT kann eine solche Informationsaufbereitung verständlicher, öffentlichkeitswirksamer und für weitere Forschungsdisziplinen durchgeführt werden. In diesem Zusammenhang ist auch die Frage nach einer Steigerung des Mehrwerts gesundheitsrelevanter Umweltinformationen von Bedeutung.

Das Vorhaben der EnviroInfo 2012-Konferenz verfolgt darüber hinaus das Ziel, das interdisziplinäre Netzwerk aus Behörden, Forschungseinrichtungen sowie klein- und mittelständigen Unternehmen zum wissenschaftlichen Austausch zusammenzubringen. Inhaltlich stehen Themen wie Umweltinformationsvermittlung zu den Bereichen Umweltschutz, nachhaltige Entwicklung und Risikomanagement im Blickfeld.

[1] http://www.enviroinfo2012.org
[2] http://ec.europa.eu/environment/seis/

2. Darstellung der Arbeitsschritte und der angewandten Methoden

Dem Querschnittsbereich Umwelt und Gesundheit widmen sich Forschungseinrichtungen, Versicherungen, Betriebe, politische Institutionen, Nichtregierungsorganisationen und weltweite Organisationen. Beispiele dazu sind in Deutschland das Aktionsprogramm Umwelt und Gesundheit (APUG[3]), auf Europäischer Ebene „Environment and Health“ der WHO[4] und der Teilbereich „Human Health and Safety“ im Europäischen Programm „Infrastructure for Spatial information“ INSPIRE[5]. Grundlage solcher Aktivitäten sind Informationen aus Datenerhebungen und deren Aufbereitung sowie die Verbreitung auf Basis innovativer Informatikanwendungen. Dies können „intelligente“ Suchmaschinen, wie PortalU[6], Geografischen Informationssystemen[7] und Social Web Anwendungen[8], die den Zugang zu gesundheitsrelevanten Daten und Inhalten ermöglichen.

Infolge einer Kluft zwischen politischen Zielvorstellungen, gesellschaftlichen Notwendigkeiten und den in Fachdisziplinen gesammelten Wissens entsteht nur zögerlich ein Fortschritt im Schaffen eines einheitlichen Zuganges zu Europäischer Umweltinformation. Aus diesem Grund wurde von Mitarbeitern im Fachausschuss Umweltinformatik im EU Forschungsprogramm „Informations- und Kommunikationstechnologies for Environmental Sustainability Research“ ICT-ENSURE[9] Empfehlungen für einen einheitlichen Zugang zu Umweltinformation[10] entwickelt.

Im Rahmen des Vorhabens der Jahreskonferenz EnviroInfo 2012 mit dem Motto „Man ● Environment ● Bauhaus – Light up the Ideas of Environmental Informatics“ im Umweltbundesamt Dessau wurden Beispiele zur Bündelung gesundheitsrelevanter Umweltinformation u.a. mit einem Fokus auf Chemikaliensicherheit eingebracht. Dabei wurde auch Verbindung mit dem Fachausschuss Umweltinformatik im Rahmen der EnviroInfo Dessau 2012 der Workshop „Kommunikation umweltbezogener Gesundheitsvorsorge“ durchgeführt. Eingeladen waren Experten der Fachdisziplinen Gesundheit und Informatik, die ihre Vorstellungen zu diesem Themengebiet eingebracht und konkretisiert haben. Die erarbeiteten Ergebnisse als auch zuvor veröffentlichte Arbeiten zu Umwelt und Gesundheit der vom Fachausschuss Umweltinformatik organisierten EnviroInfo Konferenzen können dem ICT-ENSURE Literaturinformationssystem[11] mit Eingabe des Suchbegriffs „Health AND Environment“ entnommen werden.

Im Spannungsfeld des Risikomanagements von gesundheitlichen Belastungen verursacht von Umweltstressoren spielt der gesundheitliche Umweltschutz mit den Themenfeldern:

- Methodik der Datenauswertungen,
- Darstellung der Ergebnisse (Visualisierung, Webpräsentation)
- Zielgruppenorientierte Angebote von umwelt- und gesundheitsbezogenen Daten und Informationen

[3] http://www.apug.de
[4] http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health
[5] http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2/list/7 Annex III, Human Health and Safety
[6] http://www.portalu.de/
[7] http://gis.uba.de/GISUcatalog/Start.do
[8] http://www.youtube.com/umweltbundesamt
[9] http://www.ict-ensure.eu
[10] http://ict-ensure.tugraz.at/en/index.php/ensure/Organisational-Content/Downloads-Resources/Deliverables/WP-7-SISE-Concept-Outline
[11] http://lit.ict-ensure.eu

eine wesentliche Rolle.

Die zielgruppenorientierte Kommunikation von Ergebnissen der gesundheitlichen Umweltbeobachtung und deren gesundheitlicher Bewertung ist daher nicht nur für die Öffentlichkeit/den einzelnen Bürger von Bedeutung, sondern auch für die an Arbeitsplätzen betroffenen Beschäftigten, die einer gewissen Exposition von Schadstoffen ausgesetzt sind. Die Kommunikation an die politische Entscheidungsebene erfordert einen anderen methodischen Ansatz, als z.B. an die Öffentlichkeit.

Die Tatsache, dass Daten und Informationen adressatengerecht d.h. verständlich und nachvollziehbar kommuniziert werden müssen, führt zu stärkeren handlungsorientierten Maßnahmen – sei es im Verbraucher- und/oder (betrieblichen) Umweltschutz. Wesentliche Triebfeder dieser Kommunikationsstrategien ist letztendlich der Schutz der menschlichen Gesundheit.

Durch die Kombination ökologischer und gesundheitlicher Wirkungen können ökonomische Konsequenzen von durch Umweltdaten (aus der Umweltbeobachtung) identifizierte Umweltbelastungen gesamtgesellschaftlich abgeleitet werden. Die daraus resultierenden (vermeidbaren) Kosten sind – neben einer Kosten-Nutzen-Analyse für Minderungsstrategien – wichtige Triebkraft für die Entwicklung von innovativen Lösungen im Umweltinformatikbereich.

3. Ergebnisse und Diskussion

Mit der Fokussierung der EnviroInfo 2012 auf das Thema Umwelt und Gesundheit konnte die Lücke der Informationsvermittlung weiter geschlossen werden. Im Rahmen des Workshops „Kommunikation umweltbezogener Gesundheitsvorsorge“ wurden acht begutachtete Beiträge ausgewählt und präsentiert.

Die Autoren Voigt, Scherb und Kusmierz untersuchen in ihrem Beitrag „Sex Odds an Important Indicator for Changes in Environmental Health“ mögliche Veränderungen der (üblicherweise gleichverteilten) Ausprägung des weiblichen und männlichen Geschlechts bei Neugeborenen in der Nachbarschaft von Atomanlagen bzw. Chemiebetrieben. Eine erste Analyse der Datenlage zeigt, dass Veränderungen der Verteilung des Geschlechts bei Neugeborenen durchaus ein vielversprechender Indikator für den Bereich Umwelt und Gesundheit darstellen kann.

In dem Beitrag „Analysing Health Risks from Air Pollution Effects in Saxony, Germany“ von den Autoren Richter, Wiemann, Karrasch, Kadner, Brauner, Siegert, Rossmann, Elsner und Arloth wird eine Fallstudie für ein Designkonzept einer Geoinformationsinfrastruktur im Hinblick auf die komplexen Beziehungen zwischen Luftqualität und ihrem Einfluss auf die Gesundheit des Menschen vorgestellt. Diese Infrastruktur beinhaltet ein Konzept für einen Zugang, zur Analyse und zur Visualisierung von umwelt- und gesundheitsbezogenen Daten.

Der Beitrag „Avian Influenza: Risks, Impacts and Policy Implications“ von dem Autor Armbruster setzt bei dem internationalen Problem der Geflügelpest an und stellt fest, dass eine globale Datenbank zu dieser Thematik unbedingt erforderlich ist, um diesen Aspekt einer Gefahr für Umwelt und Gesundheit des Menschen sinnvoll zu begegnen.

Die Autoren Hřebíček, Hodinka, Motyčka, Popelka und Trenz gehen in ihrem Beitrag „Environmental and Sustainability Indicators: Case Study for Agriculture and Food Processing Sector“ der Frage der passenden Umwelt- und Nachhaltigkeitsindikatoren in der Landwirtschaft sowie in der Lebensmittelindustrie nach. Diese Indikatoren sollen einen größeren Umwelt- und Gesundheitsbezug aufweisen, da sie durch eine Kombination aus überbetrieblichen und betrieblichen Indikatoren gebildet werden.

Der Beitrag „Annotation of Environmental and Epidemiological Systems; TaToo case study“ von den Autoren Kubásek, Hřebíček und Kalina berichtet über das Zusammenführen einer Datenbank über Verschmutzung durch persistente organische Chemikalien mit epidemiologischen Daten um Erkenntnisse der Auswirkungen persistenter organischer Chemikalien auf die Gesundheit des Menschen zu gewinnen. Im Blickpunkt stehen dabei auch die Wirkungen persistenter organischer Chemikalien auf den Klimawandel.

In dem Beitrag „Application of Sensor Web Technology for Analysing Correlations between Health and Environmental Data“ der Autoren Jirka, Brauner, Bröring, Kunz, Simonis und Watson werden die komplexen Beziehungen zwischen Umwelt und Gesundheit untersucht. Zur Unterstützung von Fragestellungen aus diesem Themengebiet wird eine Geoinformationsinfrastruktur vorgestellt, die eine Verbindung von umwelt- und gesundheitsbezogenen Daten für gezielte Analysen ermöglicht. In diesem Zusammenhang wird auch auf das Sensor Web eingegangen, eine Konzeption für umwelt- und gesundheitsbezogene Sensordaten.

Die Autoren Davila, Bešlić, Pečar-Ilić und Šega befassen sich in ihrem Beitrag „ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb“ mit der Echtzeit-

Darstellung von Daten der Luftqualität der Stadt Zagreb. Diese umwelt- und gesundheitsrelevanten Informationen werden automatisiert zusammengetragen aus einem Netz von Messstationen und sind über das Internet abrufbar.

Einen Überblick über das Themengebiet Umwelt und Gesundheit bzw. eine gute Möglichkeit zur Einordnung der erreichten Ergebnisse wird in dem Beitrag „Interlink between Environment and Health Information" vom Autor Pillmann gegeben. Zunächst wird aufgezeigt, dass die Beschreibung eines spezifischen Zustands der Umwelt durch Umweltdaten und Umweltinformationen auch eine gute Grundlage zur Beschreibung der jeweiligen Lebensqualität ist. Deshalb wird in diesem Beitrag genauer auf die Koppelung von Umwelt- und Gesundheitsdaten eingegangen. Im Ergebnis wird ein Metamodell (siehe Abbildung 1) vorgestellt, welches die Unterstützung von Umweltinformationen für die Betrachtung von umwelt- und gesundheitsbezogenen Fragestellungen unterstreicht.

Über den Workshop „Kommunikation umweltbezogener Gesundheitsvorsorge" hinaus wurden Erkenntnisse gesundheitsrelevanter Umweltinformation im Rahmen der EinviroInfo 2012 vor allem im Hinblick auf Chemikaliensicherheit gewonnen.

Der Beitrag „Chemicals in our life – Communication Strategies for Chemical Information under Reach" von der Autorin Knetsch zeigt auf, wie Informationssysteme über Chemikalien helfen können, umwelt- und gesundheitsrelevante Fragestellungen besser verstehen zu können, denn das Anliegen einer Chemikaliensicherheit ist eines der wesentlichen Fragestellungen unserer Gesellschaft – vor allem aus dem Blickwinkel der Gesundheit des Menschen und des Umweltschutzes.

Die Autoren Menger, Bandholtz, Ackermann und Jaspert befassen sich in ihrem Beitrag „Modular Information System on Chemicals – From Concept to Reality" mit den technischen Herausforderungen und Chancen des Informationssystems zur Chemikaliensicherheit (ICS), welches in den letzten 15 Jahren im Deutschen Umweltbundesamt aufgebaut wurde.

In dem Beitrag „BIG Kosmos: a cosmos of chemical information" von der Autorin Kuyken wird ein Konzept zur multilingualen Verarbeitung von Informationen über Gefahrgüter vorgestellt. Im Mittelpunkt dabei steht die grenz- und sprachüberschreitende Verarbeitung von Sicherheitsdatenblättern.

Der Beitrag „Dioxin Database – An Approach of Congener-Specific Data Analysis" von den Autoren Gärtner, Knetsch, Raab und van Nouhuys wird eine Datenbank vorgestellt, die es ermöglicht, Aussagen über Zeitverläufe und artverwandte Profile von persistenten organischen Chemikalien zu erhalten.

Insgesamt wurden auf der EnviroInfo 2012 im Bereich Umwelt und Gesundheit eine Vielzahl wissenschaftlicher Diskussionen geführt und in Form von Beiträgen veröffentlicht (siehe dazu auch den Anhang).

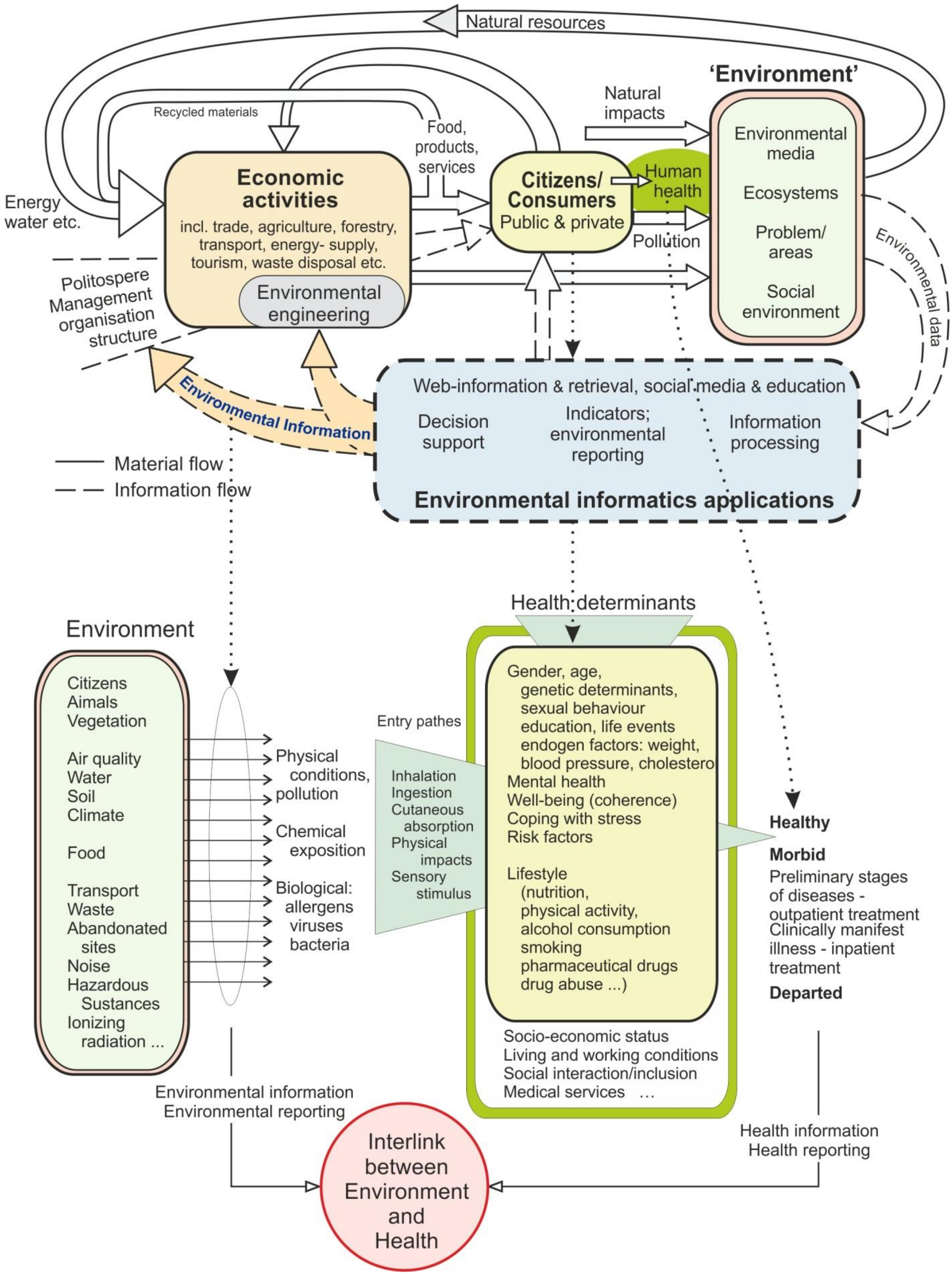

Abbildung 1: Die Bedeutung der Informatik für das Aufzeigen von umweltbeeinflussten Gesundheitseffekten (Quelle: Pillmann, W. (2012): Interlink between Environment and Health Information)

4. Öffentlichkeitsarbeit und Präsentation

Mit der Ausgestaltung der 26. EnviroInfo im Umweltbundesamt Dessau unter der Federführung des Fachausschusses Umweltinformatik zeichnet sich eine Wissenschaftlergruppe verantwortlich, die seit mehr als 25 Jahren Erfahrungen in der Ausgestaltung derartiger international anerkannter und sichtbarer Veranstaltungen hat. Der Fachausschuss Umweltinformatik ist Teil der Gesellschaft für Informatik, die in einen gesellschaftlichen Kontext der Lebenswissenschaften eingebettet ist. Die Ausgestaltung der Konferenzen umfasst neben der Organisation von spezifischen Workshops auch die Verleihung des „Environmental Informatics Prize for Students“, welcher ein öffentlichkeitswirksamer Anreiz für Nachwuchswissenschaftler ist, Kreativität und Innovation in die Umsetzung von Umweltthemen unter Nutzung modernster IT-Kommunikationswerkzeuge und -instrumente einzubringen.

Die Beiträge zur Tagung EnviroInfo 2012 sind in Druckform digital frei zugänglich über das Portal: ICT-ENSURE[12].

[12] http://iai-uiserv1.iai.fzk.de/ictensure/site?mod=litdb

5. Fazit

Im Rahmen der Konferenz EnviroInfo 2012, die vom 29. bis 31.08.2012 im Umweltbundesamt in Dessau stattgefunden hat, konnte eine erste interdisziplinäre Aufbereitung des Themas „Kommunikation umweltbezogener Gesundheitsvorsorge“ vorgenommen werden.

Durch die Anwesenheit von Experten aus Umweltforschung und Informatik wurde das übergreifende Ziel, umweltrelevante Gesundheitsinformationen zielgruppenorientierter zu kommunizieren und eine zukunftsorientierte Perspektive zu entwickeln, erreicht. Besondere Beachtung fanden dabei auch die Europäischen Programme in INSPIRE[13] (Annex III „Health“) und die Entwicklungen zu einem „Shared Environmental Information Space“ (SEIS).

[13] Infrastructure for Spatial Information in the European Community

A. Anhang

A.1. Sex Odds in Important Indicator for Changes in Environmental Health (Voigt K./Scherb, H./Kusmierz, R.)

Voigt K./Scherb, H./Kusmierz, R. (2012): Sex Odds in Important Indicator for Changes in Environmental Health. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 55-59.

Sex Odds an Important Indicator for Changes in Environmental Health

Kristina Voigt [1], Hagen Scherb[1], Ralf Kusmierz[2]

Abstract

The aim of our research is to investigate sex odds trends in the vicinity of nuclear facilities and chemical plants in Germany. We collected human sex odds data from the nineteen fiftieth till 2010. To assess time trends in the occurrence of boys among all live births, and to investigate whether there have been significant changes in the trend functions after distinct chemical or radiological events, we applied ordinary linear logistic regression. We give two examples, one for the trend in the human sex odds around the nuclear storage site TBL Gorleben and the second one around the chemical plant Hoechst-Griessheim after an accident in 1993. Both events (storage of nuclear casks as well as accidental release of chemicals) had a strong influence on the human sex odds at birth.

1. Introduction

Epidemiological effects of environmental pollution can be modelled in many different ways. An important indicator is the human sex ratio at birth. Sex ratio is the ratio of males to females in a population. The primary sex ratio is the ratio at the time of conception, secondary sex ratio is the ratio at time of birth, and tertiary sex ratio is the ratio of mature organisms. According to Neel and Schull [1991], the sex odds is unique among the genetic indicators. Its uniqueness arises from the fact that maternal exposure would be expected to produce an effect different from paternal exposure. For methodological reasons, we prefer "sex odds" over "sex ratio" to not confuse it with the statistical term ratio (see also statistical methods). We put the focus on the changes in the human sex odds at birth (secondary sex ratio) in our studies. The aim of our research is to investigate sex odds trends in the vicinity of nuclear facilities and chemical plants in Germany. This kind of study is called ecological study. An ecological study is an epidemiological study in which the unit of analysis is a population rather than an individual. In these cases, there is no information available about the individual members of the populations compared. Many epidemiologists consider an ecological study as inferior to non-ecological designs such as cohort and case-control studies because it is susceptible to the ecological fallacy. However, ecological studies are very useful because they can be carried out easily, quickly and inexpensively using data that are generally already available. Another advantage of ecological studies is the fact that large datasets can be analyzed, whereas non-ecological studies are extremely limited in their sample sizes due to high cost and feasibility. Moreover, analytical studies also are subject to many biases in general, and may, therefore, be even invalidated by uncontrolled confounding.

The ratio of male to female offspring at birth may be a simple and non-invasive way to monitor the reproductive health of a population. Except in societies where selective abortion skews the sex ratio (SR),

[1] Helmholtz Zentrum Muenchen, German Research Center for Environmental Health,
Institute of Biomathematics and Biometry, Ingolstaedter Landstr.1, 85764 Neuherberg, Germany, kvoigt@helmholtz-muenchen.de

2 Bremen, kusmierz@t-online.de

approximately 105 boys are born for every 100 girls. The authors concluded from a large retrospective cohort study that the sex ratio at birth is remarkably constant [Ein-Mor et al., 2010].

2. Evaluation Method for Human Sex Odds at Birth

2.1 Geo-spatial background and requirements

Kusmierz et al. [2012] gave an overview on the data sources for modeling epidemiological effects of environmental pollution. They explained the special situation and challenges in collecting, handling and analyzing the human sex odds data in Germany. The geographic coordinates given in the Gauss–Krüger coordinate system are used. The Gauss–Krüger coordinate system is a special transverse Mercator map projection used in Germany, Austria and Finland rather than the UTM-system but similar to this. The central meridians of the Gauss–Krüger zones are only 3° apart, as opposed to 6° in UTM. A transverse Mercator map projection approximates the reference ellipsoid by a cylinder sector, which perimeter smoothes the central meridian of the mapped zone some depth below the reference surface, so the elliptical cylinder intersects the ellipsoid. The transverse Mercator map projection provides a nearly conformal mapping of earth's surface in smaller regions, so distances can simply be computed by using the Euclidean distance from the numerical differences of the coordinate components with very small errors.

Before and after the German reunification, the lowest administrative levels (NUTS- 3-regions) split into districts, which are either cities or management associations from municipalities. The smallest statistical units information is published for, the community, may be rather different in size, e.g., the large metropolises Berlin, Frankfurt, Munich, are single municipalities, and the smallest municipalities have fewer than 10 residents. The data provided by the statistical offices for the states can sometimes be downloaded from the Internet. For other states, fees must be paid for the data. The states of Schleswig-Holstein and Hamburg, and of Brandenburg and Berlin each have a joint National Institute of Statistics, respectively. From 2008, birth data can be downloaded free of charge via the Internet from the "regional database" at the German Federal Statistical Office DESTATIS for all communities under the URL https://www.regionalstatistik.de.

2.2 German Municipalities 1957 to 2010

Kusmierz et al. [2010] compiled official gender specific annual live births statistics for all municipalities in Germany. To calculate the distances of the municipalities from nuclear facilities, we determined uniform coordinates for the geographic positions of those municipalities including the geographic positions of 28 pertinent nuclear facilities including all nuclear power plants in Germany and Switzerland. We now use the same data background for the evaluation of the sex odds in the vicinity of chemical sites in Germany.

2.3 Statistical Methods: Ordinary Linear Logistic Regression

To assess time trends in the occurrence of boys among all live births, and to investigate whether there have been changes in the trend functions after distinct events, we applied ordinary linear logistic regression. This involves considering the male proportion among all male (m) and female (f) births: $p_m = m/(m+f)$. Important and useful parameters in this context are the sex odds: $SO = p_m/(1- p_m) = m/f$, and the sex odds ratio (SOR), which is the ratio of two interesting sex odds if those two sex odds have to be compared, e.g. in exposed versus non-exposed populations. We used dummy coding for single points in time and for time periods as well. For example, the dummy variable for the time window from 1994 on is defined as d94(t) = 0 for t < 1994 and d94(t) = 1 for t ≥ 1994. The simple and parsimonious logistic model for a trend and a jump in 1994 has the following form (LB = live births):

$$\text{Boys}_t \sim \text{Binomial}(\text{LB}_t, \pi_t)$$

$$\log\ \text{odds}\left(\pi_t\right) = \text{intercept} + \alpha * \text{t} + \beta * \text{d}_{1994}(\text{t})$$

To allow for changing sex odds trend slopes (broken sticks) after chemical or radiological events, we used dummy coding of time windows and interactions of those time windows with time. The data in this study were processed with Microsoft Excel 2003. For statistical analyses, we used R 2.11.1, MATHEMATICA 8.2, and mostly SAS 9.2 (SAS Institute Inc: SAS/STAT User's Guide, Version 9.2. Cary NC: SAS Institute Inc; 2003).

3. Evaluating Nuclear Facilities and Chemical Plants in Germany

3.1 Nuclear Facilities

A study performed by the authors [Kusmierz et al., 2010] and [Scherb and Voigt, 2011] revealed an increase in sex odds in the vicinity of running nuclear facilities, especially around the nuclear storage site TBL Gorleben (Transportbehälterlager: nuclear waste shipping casks storage) in Lower Saxony, Germany. In Germany a continuous discussion about the nuclear waste shipping casks storage in Gorleben increased our interest in taking a closer look at this location. We published a spatial sex odds distance law according to a Rayleigh function, and a temporal trend function including a simple jump (change-point analysis) [Scherb and Voigt, 2012].

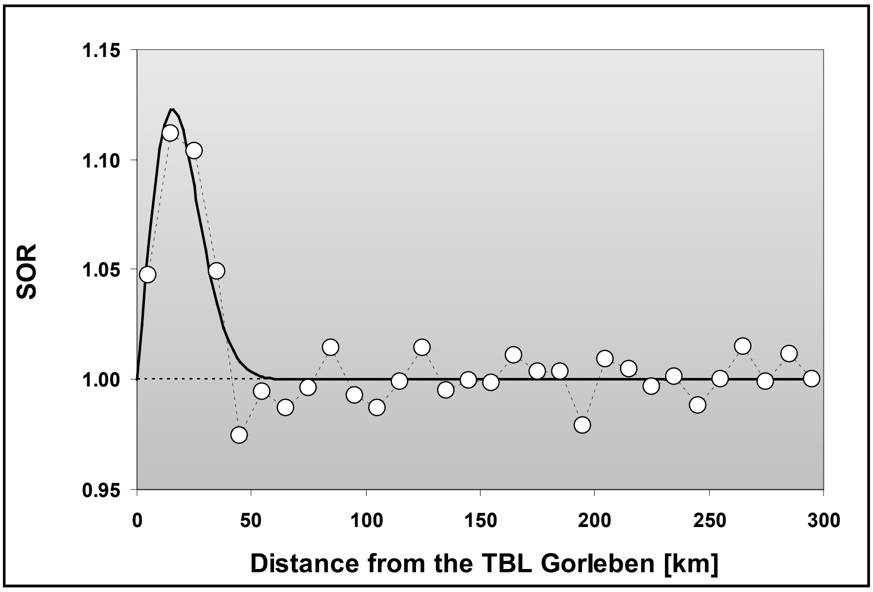

Figure 1
Rayleigh function for the evaluation of distance trends from the TBL Gorleben

In Figure 1, the distance law of the sex odds ratio (SOR) of aggregated live birth data for 10 km distance rings, after vs. before the first Castor went to Gorleben in April 1995 is demonstrated. The F-test p-value is 0.0090, which means that the Rayleigh curve significantly improves the fit to the data compared to the intercept-only model. A distinct increase in the human sex odds at birth within 40 km distance from Gorleben compared to far distances can clearly be stated. In this approach, approximately 23.5 million births are considered.

3.2 Chemical Plants

We performed the same analysis described under section 2.3 on chemical sites in Germany. Results of this first screening approach can be found in the Proceedings of the iEMSs Conference 2012 [Voigt et al., 2012, submitted]. In this paper we also considered the influence of chemical accidents on the sex odds. We therefore took a closer look at the live birth sex odds in the vicinity of Hoechst – Griesheim, where an accident took place in 1993. During this accident approximately 11.8 tons of chemical mixtures containing mostly chlorinated nitroarenes were emitted leading to serious contaminations in Schwanheim/Goldheim, a nearby housing area. Numerous inhabitants of the contaminated area complained of irritation of eyes, skin and mucous membranes, headache and nausea, and 92 persons with moderate symptoms were reported to the National Health Department [Heudorf et al., 1994].

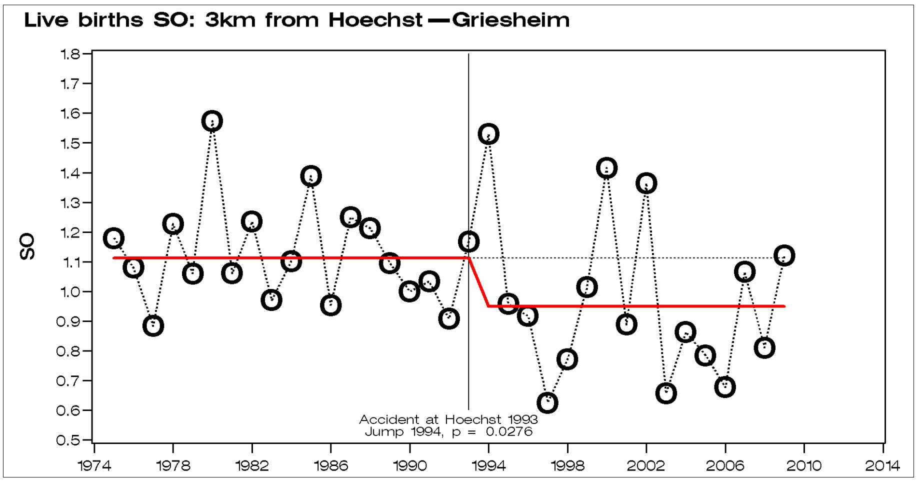

Figure 2
Sex odds 3 km from Hoechst-Griesheim

We therefore looked at the live birth sex odds in the vicinity of Hoechst – Griesheim (see Figure 2). Here we detected a remarkable decrease in sex odds after the chemical accident. The p-value 0,0276 indicates a considerable significant effect. For this graphical output 5.203 live births were considered from 1975 to 2009.

4. Summary and Outlook

Some environmental hazards can alter the sex ratio at birth. In a recently published review article [Terrell et al, 2011] 100 studies were evaluated including several studies on ionizing radiation and chemicals. Most of these studies are non-ecological ones. The range of cases only was between tens and thousands, which clearly are much too small numbers in order to detect genuine determinants of the secondary sex odds in humans.

In our ecological studies we take a look at a huge number of cases. The studies on sex odds with respect to accidents with ionizing radiation clearly indicated strong effects in the direction of an increase in sex odds [Scherb and Voigt, 2009, 2011, 2012]. We made one investigation around a chemical plant where a major chemical accident took place in 1993. Here we found a significant effect on the sex odds, say a decrease in sex odds. Both increase and decrease in the human sex odds at birth provide a strong indication that there is an impact of man-made facilities on the human genome. Further background concerning this issue is given by Sperling et al. [2012].

We demonstrated that the indicator "sex odds at birth" is a strong one showing the influence of ionizing radiation and chemicals on human health. Furthermore, we support the importance of ecological studies in this respect, as the data are available and the datasets are much larger as in cohort and case-control studies. The latter cost a lot of money and also have several deficiencies, e.g. missing data only to name one.

We are continuing our research in this area trying to prove that nuclear facilities as well as chemical sites pose a risk to the environment and to human health. Complete data sets in Germany as well as French birth statistics will be analyzed in the near future.

Bibliography

Ein-Mor E, Mankuta D, Hochner-Celnikier D, Hurwitz A, Haimov-Kochman R (2010) Sex ratio is remarkably constant. Fertil Steril 93 (6):1961-1965.

Heudorf U, Neumann HG, Peters M (1994) Accident in the Hoechst AG company 22 February 1993. 2. Public health evaluation. Gesundheitswesen 56 (7):405-410.

Kusmierz R, Voigt K, Scherb H (2010) Is the human sex odds at birth distorted in the vicinity of nuclear facilities (NF)? A preliminary geo-spatial-temporal approach. In: Greve K, Cremers AB (eds) Integration of Environmental Information in Europe, Bonn, 2010. Shaker Verlag, Aachen, pp 616-626.

Kusmierz R, Scherb H, Voigt K (2012) Overview on data sources for modelling epidemiological effects of environmental pollution. In: Seppelt R, Voinov AA, Lange S, Bankamp D (eds) International Environmental Modelling and Software Society (iEMSs) 2012, Leipzig, Germany, 2012.

Neel JV, Schull WJ (1991) The children of atomic bomb survivors: a genetic study. National Academy, Washington, D.C., USA.

Scherb H, Voigt K (2009) Radiation-Induced Genetic Effects and the Chernobyl Nuclear Power Plant Accident. Acta Paediatrica 98:51-51.

Scherb H, Voigt K (2011) The human sex odds at birth after the atmospheric atomic bomb tests, after Chernobyl, and in the vicinity of nuclear facilities. Environ Sci Pollut Res Int 18 (5):697-707. doi:10.1007/s11356-011-0462-z

Scherb H, Voigt K (2012) Response to W. Kramer: The human sex odds at birth after the atmospheric atomic bomb tests, after Chernobyl, and in the vicinity of nuclear facilities: comment Environ Sci Pollut Res Int 19 (4): 1335-1340. doi:DOI: 10.1007/s11356-011-0644-8.

Sperling K, Neitzel H, Scherb H (2012) Evidence for an increase in trisomy 21 (Down syndrome) in Europe after the Chernobyl reactor accident. Genet Epidemiol 36:48-55.

Terrell ML, P. HK, Macrus M (2011) Can environmental or occupational hazards alter the sex ration at birth? A systematic review. Emerging Health Threats Journal 4 (7109). doi:DOI: 10.3402/ehtj.v4i0.7109

Voigt K, Scherb H, Kusmierz R Chemicals' risks versus radiation risks with respect to the alteration of human sex odds: a preliminary evaluation approach. In: Seppelt R, Voinov A, Lange S, Bankamp D (eds) International Environmental Modelling and Software Society (iEMSs) 2012, Leipzig, Germany, 2012.

A.2. Analysing Health Risks from Air Pollution Effects in Saxony, Germany (Richter, S./Wiemann, S./Karrasch, P./Kadner, D./Brauner, J./Siegert, J./Rossmann, J./Elsner, B./Arloth, J.)

Richter, S./Wiemann, S./Karrasch, P./Kadner, D./Brauner, J./Siegert, J./Rossmann, J./Elsner, B./Arloth, J. (2012): Analysing Health Risks from Air Pollution Effects in Saxony, Germany. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 69-75.

Analysing Health Risks from Air Pollution Effects in Saxony, Germany

Silke Richter, Stefan Wiemann, Pierre Karrasch, Daniel Kadner, Johannes Brauner[1], Joachim Siegert, Julia Rossmann, Bernhard Elsner, Jana Arloth[2]

Abstract

This article presents the approach and current findings of the EO2HEAVEN project, in particular from the Saxony Case Study. The aim of the Case Study is the conceptual design of a Spatial Information Infrastructure for better understanding the complex relationship between ambient air quality and its influence on the human health. This includes air quality modelling and a statistical analysis of health datasets as well as the development of a service infrastructure offering access, analysis and visualization of environmental and health information.

1. Introduction

The adverse effect of air pollution and extreme meteorological conditions to the human health is already well known and documented (WHO 2004c, EEA 2011). This usually becomes evident by an influence on acute as well as chronic respiratory and cardiovascular diseases. According to the World Health Organization (WHO) air pollution is a ubiquitous environmental problem in industrialised countries. Above all, particulate matter (PM) and ground-level ozone (O_3) are reported to have the strongest negative impact on human health. However, other air pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO_2) or carbon monoxide (CO) as well as extreme meteorological conditions must not be underestimated (EEA 2010, EEA 2006, WHO 2008, WHO2004a). The term air quality as referred to in this paper is a combination of both air pollution and meteorological conditions.

To warn and protect the population from poor air quality, there is an increasing demand for spatial and temporal precise and detailed information on air pollution and meteorological conditions. Especially regional air quality conditions are required to take appropriate actions for air quality improvement as well as for health prevention (WHO 2004b, WHO 2004c, Baklanov 2007).

The development of a better understanding of the complex relationships between air quality and health impacts is the overall objective of the EU-funded project *Earth Observation and Environmental Modelling for the Mitigation of Health Risks* (EO2HEAVEN). The project started in 2010 with a duration of three years. From in total three case studies, two deal with air quality and its impact on the respiratory and cardiovascular system. This includes an improvement of the usability and provision of air quality information as well as an analysis of its potential health impact. By integrating the public health sector and strong cooperation with information technology, EO2HEAVEN follows a multidisciplinary and user-oriented approach. The result of this collaboration is the design and development of a distributed Spatial Information Infrastructure (SII) fostering the investigation on environmentally related health risks and ultimately supporting public health decision making. This paper presents current findings and challenges in the project EO2HEAVEN focussing the Case Study of Saxony, Germany.

[1] Professorship of Geoinformation Systems, Technische Universität Dresden, Germany

[2] Research Association Pubblic Health Saxony and Saxony-Anhalt, Technische Universität Dresden, Germany

2. Overview on the Case Study of Saxony

The objective of the EO2HEAVEN Case Study described in this paper is the federal state of Saxony, Germany. From the economical, ecological and social perspective, Saxony represents a typical region in central Europe. The landscape divides into mountains, hills and plains with cold-moderate to continental climatic conditions. Furthermore, the demographic structure of Saxony corresponds to a typical development within many European countries characterized by an increase of the percentage of elderly population (Sächsische Staatskanzlei 2006).

The Case Study focuses on respiratory and cardiovascular diseases in relation to the environmental parameters O_3, PM_{10}, SO_2 and NO_2. Although air quality can be considered good in average, the thresholds (according to the EU-Directive 2008/50/EC) for ground-level O_3, PM_{10} and NO_2 are regularly exceeded at the measuring stations. SO_2 concentrations are fortunately far below the threshold (LfULG 2011).

There are mainly two main goals of the Case Study: 1st is to study the potential impact of air quality to the human health and 2nd is to develop an SII providing the means for analysing and visualizing environmental and health information. As health authorities are responsible for health promotion, health reporting as well as social and health advisory services, they are expected to be the main users of the SII. To clarify the requirements that end users expect, a number of interviews have been conducted. Most of the interviewees stated that examining the actual impact of air quality on the population is of great importance. Missing computational and personal resources, missing scientific support and a lack of available tools have been identified as the major drawbacks in current data analysis.

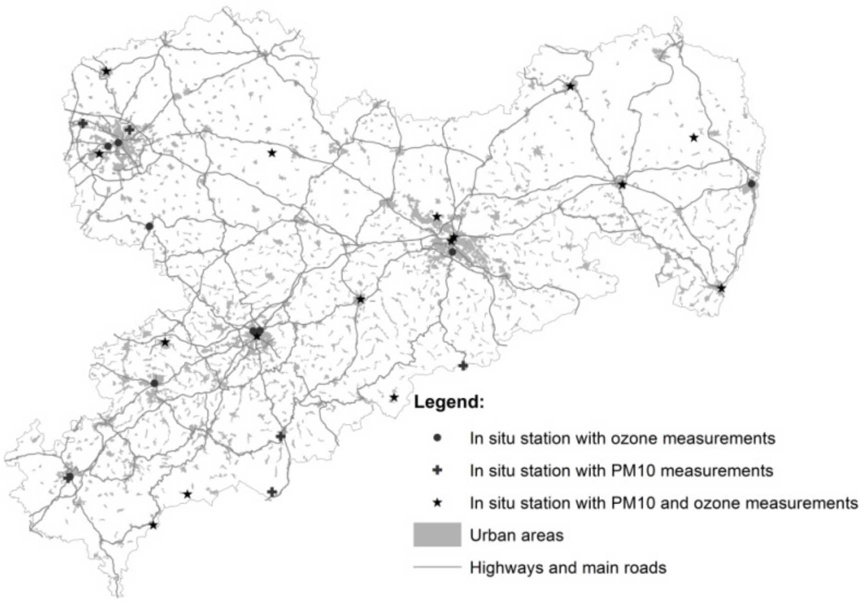

Figure 1
in situ sensor network for PM_{10} and O_3 immission in Saxony (2006)

To overcome the mentioned disadvantages, a number of environmental and health data sets are required. To comply with the EU-Directive 2008/50/EC, pollutant concentrations and additional meteorological parameters are measured by an in situ station network operated by the Saxon State Office for Environment, Agriculture and Geology (LfULG). Most of the parameters are half-hourly measurements. The sensor network distribution for O_3 and PM_{10} measurements is shown in Figure 1.

Another source of environmental data taken into account is remote sensing which usually covers a much larger area. However, since the whole atmosphere is measured it is not possible to directly extract ground concentrations for air quality parameters from the data. Thus, approaches to derive ground level concentrations are required.

Concerning O_3 the NASA (National Aeronautics and Space Administration) provides the Ozone Monitoring Instrument (OMI) offering vertical profiles of tropospheric ozone at different pressure levels. The comparison of the satellite measurements of the lowest pressure level with the in situ data shows that it is currently still a challenge to determine ground-level ozone using satellite data.

PM_{10} can be described as a function of the atmospheric opacity with the aerosol optical depth (AOD) as an indicator. The AOD is provided as a derivative product from the NASA MODIS (Moderate Resolution Imaging Spectroradiometer) instrument which is placed on board of the Terra and Aqua Satellites. A number of studies demonstrate that it is feasible to determine a mathematical relationship between the AOD-value and its corresponding PM_{10}-value (Emili 2010; Koelemeijer 2006). Within the Case Study only a poor correlation between remote sensing and in situ observations for both O_3 and PM_{10} was found. Furthermore the use of remote sensing data is limited due to frequent cloud cover, especially in Central Europe.

For studying the impact of air quality on the human health two health data sources were used within the Case Study. The 1st is a database from the Allgemeine Ortskrankenkasse (AOK Plus), one of the largest public health insurance companies in Saxony. It contains personal information on the insured patients, diagnoses, treatments and prescriptions. For the study timeframe from 2005 to 2007 it contains about 150 million cases. The 2nd source is the official mortality and morbidity statistics provided by the German Research Data Centre. For both data sources, personal information is aggregated to the postal code or municipality level due to data protection. The diagnoses are classified according to the International Statistical Classification of Diseases and Related Health Problems (ICD10).

3. Methods for Environmental and Health Modelling

The modelling of continuous air pollution information from in situ sensor observations is of great interest for environmental and health risk analysis. However, the accuracy and reliability strongly relies on the number and distribution of in situ sensor stations. Because of the small number of in situ sensors for the state of Saxony, standard interpolation techniques are difficult to apply especially in sparsely covered regions. Thus, within the EO2HEAVEN project, air pollution is calculated based on affinity area calcula-

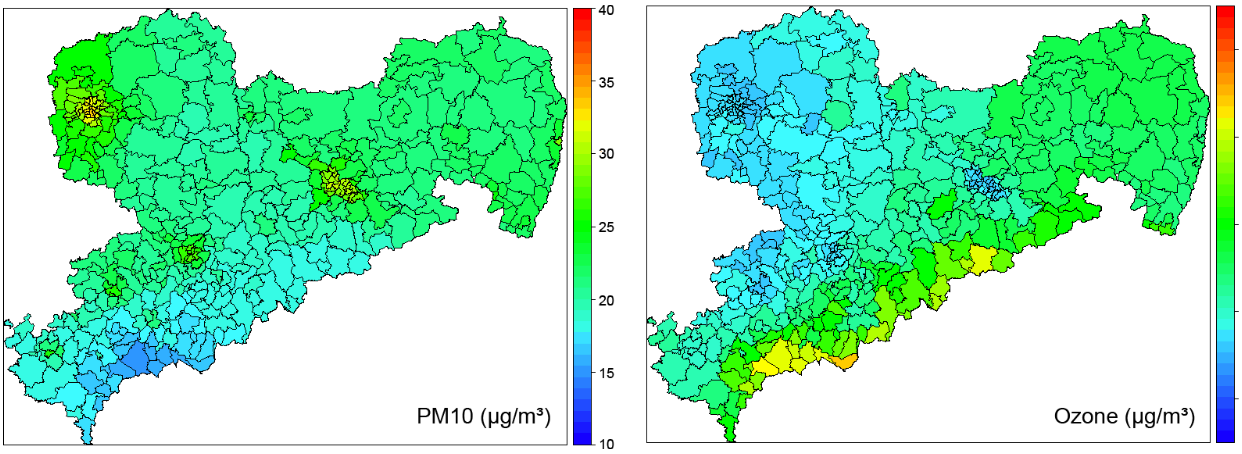

Figure 2
Modelled concentrations for PM10 (left) and Ozone (right), aggregated on the postal code level

tions. This technique has previously been applied to air pollution modelling by McGregor (1996) or the APMoSPHERE project (APMoSPHERE 2005). It asserts that “everything is related to everything else, but near things are more related than distant things” (1st law of geography, Tobler 1970) implicating that similar regions will most likely share the same air quality characteristics. Corresponding similarity measurements are based on different attributes tending to influence the considered air quality characteristic, such as land cover, elevation, traffic, and population density.

The model is implemented by a multidimensional Inverse Distance Weighting algorithm, using the previously mentioned attributes to calculate distances between each area and in situ sensor station surroundings. A more detailed description on how it works has previously been described in Wiemann et al. (2012). An inherent drawback of the model is the exclusive use of immission data, as provided by the in situ sensor network. However, it can provide robust estimations of the pollution situation and can be complemented with existing models for emission and dispersion modelling to achieve refined air pollution information. The robustness and performance of the model allows for its use in a service environment for offering real time air quality information across the internet. Examples for the corresponding calculation of PM10 and Ozone concentrations from in situ sensor observations are depicted in Figure 2.

Since the AOK Plus dataset is structured for health insurance billing purposes and not for medical research, algorithms for defining cases (e.g. involving disease-specific prescribed medication) have been developed in order to obtain a more valid measure of the health risks. For first explorative data analysis, charts have been generated, describing cases of a certain disease (e.g. asthma bronchiale) over time. For analysing the relationship between environmental pollution and health effects SAS software (Version 9.3) is used to calculate Zero-Inflated Count Negative Binomial Regression-Model(ZINB) with Logistic Link Function (Lambert 1992).

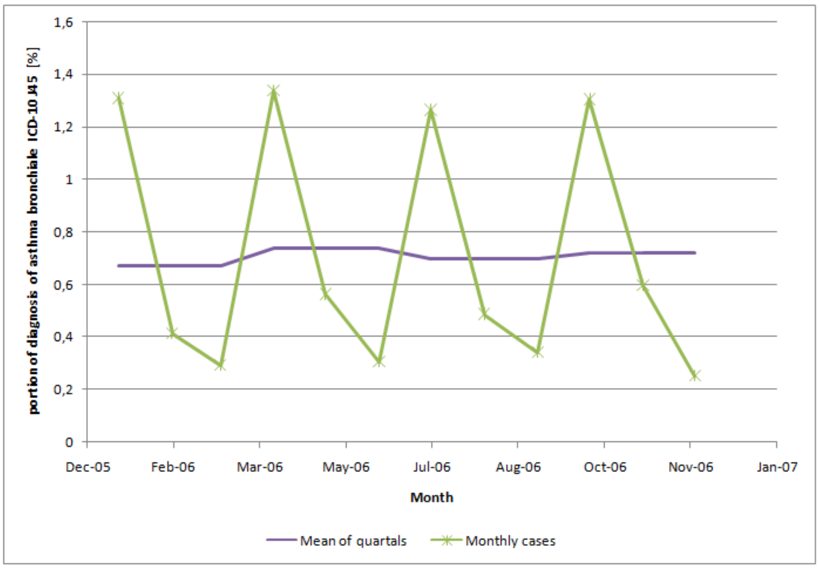

Figure 3
Cases with asthma bronchiale in Bautzen county, Saxony

What could be recognized first when analysing the descriptive charts of the relative number of Asthma bronchiale diagnosis (ICD10 J45) were effects due to organizational issues of the German primary health care system, i.e. having most of the given ICD-10 diagnosis in the first month of each quarter, because at this time-point physicians just got the budget for treating their patients, whereas at the end of the quarter they have spent most of their budget and therefore get no reimbursement for any additional treatments. Moreover, a weekday-effect was discovered, most likely influenced by the usual opening regime of physicians.

For estimating and proving the association between pollutant exposure and occurrence of diseases the used ZINB-model showed that it is hard to predict excess occurrences of cases due to exposition to PM_{10} or O_3 yet. This maybe is the fact because even defining cases from health insurance data is challenging and already at this point bias potentially could have occurred. Therefore, additionally inpatient-data of the official morbidity and mortality statistics is currently analysed, which contains data of all people admitted to hospital in Saxony. In the descriptive statistics of this dataset, there was no effect of quarter like in the health insurance dataset. Only a slight decline in hospitalization around Christmas was detected, most likely due to the fact, that planned surgeries or hospital treatments are avoided by the patients during this time and a decline in hospitalisation rate of about 10% in February (due to February having only 28 days). In order to get a more generalizable impression, currently both datasets are analysed simultaneously.

4. Architecture and Implementation of an Online System

To realize the proposed online system for historical and real time air quality retrieval, a number of web services was implemented following standards from the Open Geospatial Consortium (OGC) and the World Wide Web Consortium (W3C). The individual components are depicted in Figure 4, comprising:

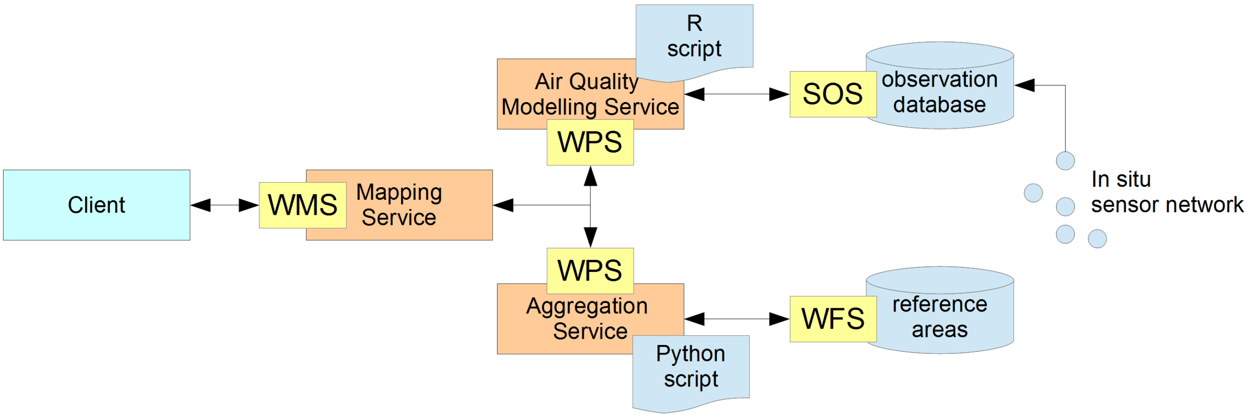

Figure 4
Service architecture for online air quality mapping

- Mapping Service offering an OGC WMS interface for time enabled air quality mapping. The service is able to communicate with an OGC WPS (Web Processing Service) interface for air quality modelling and feature aggregation,
- Air Quality Modelling Service offering an OGC WPS interface to retrieve air quality information for specified observations retrieved from an OGC SOS (Sensor Observation Service). In the backend of the service, an R script is executed to estimate the air quality using the previously described model,
- Observation database offering historical and real time observations from the LfULG in situ sensor network via OGC SOS interface,

- Aggregation Service to aggregate the air quality on specified reference areas, like administrative or postal code areas. This step is required to compare air quality with existing health statistics, as those are likewise aggregated. The aggregation is computed using Python with GDAL bindings,
- Reference area features offered via WFS (Web Feature Service) interface for aggregating the pollution concentrations.

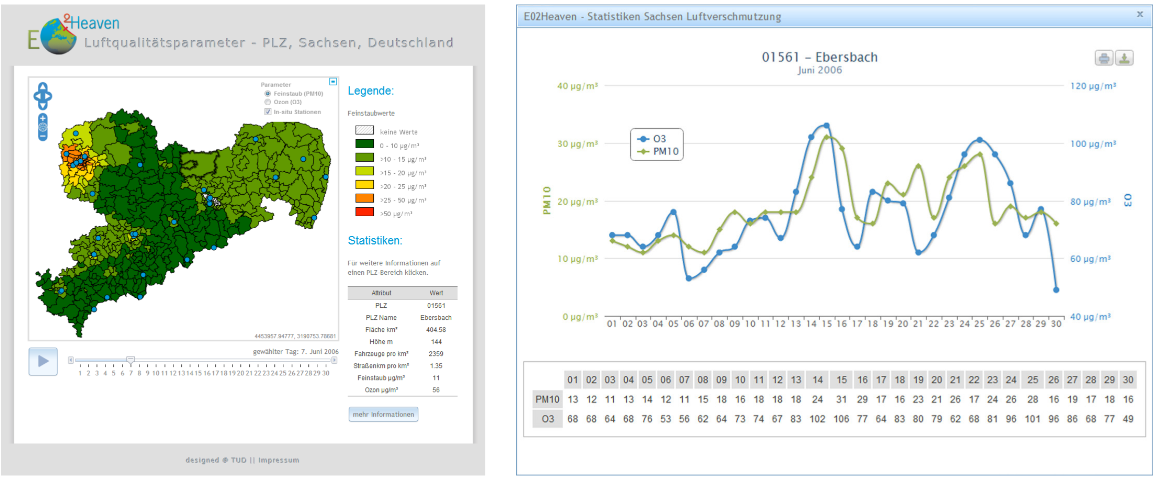

Figure 5
Time2Maps Client (left) and exemplarily produced chart (right)

For the visualization of available datasets and above mentioned services, a web application called Time2Maps (Figure 5, left side) was implemented. In general, this is a client for the interactive display of spatial data (maps) and additional information. Next to the mere visualization of static data, the user can also explore maps provided by time-aware services to examine the temporal progress of measured data like ozone, particulate matter or diseases caused by these environmental parameters. This analysis is supported by showing appropriate charts rendered by Time2Maps (Figure 5, right side).

5. Conclusion

The findings from the presented Case Study can be summarized as follows:

- There is an increasing demand for tools and means to explore, analyse and visualize datasets on air quality as well as health statistics
- From the available data currently no correlation can be found for the influence of air quality on the human respiratory and cardiovascular system
- The use of remote sensing data for air quality modelling is quite limited because of its complex linkage to in situ observations and restrictions in data availability

The functionality of the current implementation of the SII comprises tools for real-time accessing, visualizing, modelling and analysing air quality and health information. It can help to better understand the linkage between environment and health information and be used as a supporting tool for environment and health decision making.

Although current health data analysis does not reveal a link between air quality and health, it does not mean that there is none. In fact it just means that there are other influences on the analysis, such as quarter driven health data, indirect measurements of human exposure or socio-economic confounders. However, available air quality indices, such as the ones summarized by CITEAIR (2007), can be applied for health risk assessment.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 244100.

Bibliography

APMoSPHERE, 2005: 6. Detailed report, related to overall project duration. Technical report, APMoSPHERE project consortium, 2005.

Baklanov, A., Hänninen, O., Slørdal, L. H., Kukkonen, J., Bjergene, N., Fay, B., Finardi, S., Hoe, S. C., Jantunen, M., Karppinen, A., Rasmussen, A., Skouloudis, A., Sokhi, R. S., Sørensen, J. H. & Ødegaard, V., 2007: Forecasting Urban Meteorology, Air Pollution and Population Exposure. Air Pollution Modeling and Its Application XVII. S. 29-40.

CITEAIR, 2007: Comparing Urban Air Quality Across Borders – A review of existing air quality indices and the proposal of a common alternative. Technical Report, June 2007.

EEA (European Environmental Agency), 2006: Environment and health. No. 10/2005). EEA Report. Copenhagen, Denmark.

EEA (European Environmental Agency), 2010: The European Environment - State and outlook 2010 Air Pollution. Copenhagen, Denmark.

EEA (European Environmental Agency), 2011: Air quality in Europe – 2011 report. Copenhagen, Denmark, No. 12/2011.

Emili, E., Popp, C., Petitta, M., Riffler, M., Wunderle, S., Zebisch, M., 2010: PM10 remote sensing from geostationary SEVIRI and polar orbiting MODIS sensors over the complex terrain of the European Alpine region. In: Remote of Environment 114:2485-2499.

Koelemeijer, R. B. A., Homan, C. D., Matthijsen, J., 2006: Comparison of spatial and temporal variations of aerosol optical thickness and particulate matter over Europe. In: Atmospheric Environment, 40:5304-5315.

Lambert, D. (1992). Zero-inflated Poisson regression, with an application to defects in manufacturing. Technometrics 34(1): 1-14.

LfULG (Landesamt für Umwelt, Landwirtschaft und Geologie), 2011: Luftqualität in Sachsen, Jahresbericht 2010.

McGregor, G., 1996: Identification of air quality affinity areas in Birmingham, UK. In: Applied Geography, 16(2): 109–122.

Sächsische Staatskanzlei, 2006: Empfehlungen zur Bewältigung des demografischen Wandels im Freistaat Sachsen – Expertenkommission "Demografischer Wandel Sachsen".

Tobler, W., 1970: A computer movie simulating urban growth in the Detroit region. In: Economic Geography, 46(2): 234–240.

WHO, 2004a: Health Aspects of Air Pollution - Results from the WHO project „Systematic review of health aspects of air pollution in Europe". No. E83080. Denmark: WHO Europe.

WHO, 2004b: Zu einem gemeinsamen Informationssystem als Entscheidungshilfe im Bereich Umwelt und Gesundheit in Europa. No. EUR/04/5046267/10. Vierte Ministerielle Konferenz Umwelt und Gesundheit, Budapest.

WHO, 2004c: Outdoor air pollution - Assessing the environmental burden of disease at national and local levels.

Wiemann, S., Richter, S., Karrasch, P., Brauner, J., Pech, K., Bernard, L., (2012): Classification-driven air pollution mapping as for environment and health analysis. 6th International Environmental Modelling and Software Society (iEMSs), 2012, Leipzig, Germany

A.3. Avian Influenza: Risks, Impacts and Policy Implications (Armbruster. W.)

Armbruster. W. (2012): Avian Influenza: Risks, Impacts and Policy Implications. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 77-82.

Avian Influenza: Risks, Impacts and Policy Implications

Walter J. Armbruster[1]

Abstract

Avian influenza has been an ongoing concern as a zoonotic food animal disease transmissible to humans which emerged from relative isolation in Asia onto the world stage starting in 2003. The concern is that this disease will transform to become readily transmitted among humans, creating a worldwide pandemic with severe human health and economic impacts. To date, the virus has shown itself to be relatively inefficient in mutating into a human transmissible form. Nonetheless, the economic impacts of the threat of such occurrence have been significant, as they have been for other zoonotic diseases circulating internationally.

1. Human and Economic Impacts of Zoonotic Diseases[2]

Food safety is a critical element of the global food system with foods sourced from many countries around the world. Despite strong food safety systems in place in such countries as Germany and the United States, occasional food-borne illness outbreaks occur. Firms invest significant financial and human resources to prevent microbial pathogens, carcinogenic chemicals, and other harmful substances from entering their food products. Governments monitor compliance with established food safety regulations.

Another element of food production and marketing which may have even more serious repercussions for consumers involves animal diseases which can impact food supplies, international trade and human health worldwide. Particularly concerning is the potential for a zoonotic disease—an animal disease that may be transmitted to humans under natural conditions—to be transmitted from food animals to humans. Very disconcerting is the potential for the disease to become easily transmitted among humans. The most serious concern is the potential for emergence of readily transmissible forms of human influenza viruses from mutations of animal and human forms of the disease, leading to pandemic conditions.

The occurrence of zoonotic disease outbreaks has increased in recent years and is especially threatening to human health. Globalization of the food supply system and increased international travel make transmission much more rapid, perhaps even exceeding the ability to identify initial disease outbreaks and take action to isolate them. The most recent global pandemic involved the H1N1 swine flu.

1.1 2009 H1N1 (Swine Flu) Pandemic

In 2009-10, a global influenza A H1N1 pandemic occurred. It was initially referred to as the swine flu, but subsequently renamed once better information became available about it being a new influenza strain. As widely reported, the outbreak affected younger and healthier populations more so than would be expected, causing disproportionate fatalities in this subpopulation (Hendrick 2010). Another anomaly was that incidences occurred well outside the normal seasonal flu periods.

The virus did not mutate during the pandemic to a more lethal form, nor did widespread resistance to the available oseltamivir vaccine develop. The vaccine was a good match for the circulating viruses. Ex-

[1] Farm Foundation (Retired), 1709 Darien Club Drive, Darien, IL 60561; email: walt@farmfoundation.org.

[2] Adapted from Armbruster (2011).

tensive preparedness and support from the international community enabled even countries with very weak health systems to detect cases and report them promptly (WHO 2010). Laboratory-confirmed deaths caused by the 2009 pandemic influenza A H1N1 totaled 18,500 reported worldwide from April, 2009, to August, 2010 (Dawood 2012). However, Dawood and colleagues believed that this represented a small portion of actual deaths attributable to the pandemic. They estimated the number of cardiovascular and respiratory deaths in each country over the first 12 months the virus was circulating in the country to be nearly 285,000, with 80% affecting those under 65 years and 51% occurring in Southeast Asia and Africa. This is 15 times the official laboratory-confirmed tally and shows the potential human and economic impact to be considerably higher than earlier estimates.

It is difficult to determine the incidences of such pandemic outbreaks in real time. Many victims do not get reported through laboratory testing data since they are never tested. Public health informatics involves the collection of reports of communicable disease cases from doctors, hospitals, and laboratories, and is used for infectious disease surveillance; allowing display of infectious disease statistics and trends to help identify serious outbreaks. This data is mostly generated at the local levels in the U.S. as well as in other countries. It is critical information which allows scientists to later estimate the true extent of the human toll of pandemics.

The economic effects on agricultural commodity markets of the H1N1 pandemic was exacerbated by media coverage (Attavanich 2011). This was a direct effect from the early labeling and widespread publicity about “swine flu” which caused a downturn in U.S. and international pork markets. This was despite the fact that there is no relationship between H1N1 and pork consumption. Attanavich found that the U.S. hog industry suffered a market revenue loss of $200 million, equal to about 2.5% of potential revenue. The worldwide economic impacts on the pork industry would have been some multiple of this amount, not to mention other sources of economic disruption, such as through trade bans which were not justified by food safety concerns. This strongly suggests that the public policy and health research communities must take care in labeling animal disease outbreaks to keep from using names related to commodity or other economic sectors not directly involved. The problem arises because of the potential for unfounded food safety concerns to be raised which has serious consequences for the affected industry segment. Policymakers dealing in risk communications should follow the guidance of the risk communication literature. Further, they should heed the guidance of the scientists and health professionals working on the outbreak to be careful to avoid creating unwarranted fear among the populace about the impacts and any food safety issues which may be associated with the outbreak.

Lessons learned from this pandemic included the importance of early warning made possible though networks maintained by the international health focused organizations and scientists, including those in public agencies; the necessity of immediate response by national and international organizations and pharmaceutical firms to produce as much vaccine as possible quickly; the value of using the best available vaccine for massive interventions to help prevent contracting the circulating flu; the need for continued vigilance to specific characteristics of the particular outbreak, in this case the demographic uniqueness and the lengthy period of circulation beyond the normal peak flu season; and the critical need for international coordination and cooperation in the global economy now existing (Armbruster, 2011, 4). The recent Dawood (2012) report adds another lesson—Africa and Southeast Asia need to be effectively targeted in efforts to prevent influenza pandemics in the future. Certainly there are some valuable ideas from this experience which are applicable to the far more concerning H5N1 Highly Pathogenic Avian Influenza (HPAI).

1.2 H5N1 Highly Pathogenic Avian Influenza (HPAI)

H5N1 Highly Pathogenic Avian Influenza (HPAI) outbreaks which started in 2003, peaked in 2006, and a much smaller number of cases continue to occur. They have been most heavily concentrated in Indonesia, Egypt, and Vietnam (Table 1). While reported cases appear to have slowed, the major H5N1 HPAI virus reservoir of migrating and local birds, especially ducks and backyard chicken flocks, continue to pose a severe threat. Of 607 cases of laboratory-confirmed cases reported to the WHO over the 2003-2012 period,358 have been fatal (World Health Organization 2012a)—a 59% mortality rate which supports the reason for concern among scientists and policy makers. All confirmed cases have been from bird-to-human transmission in East/Southeast Asia, Eastern Europe and Africa (World Health Organization 2011). The saving grace has been the failure to date of the disease to mutate into a virus readily transmissible among humans which could lead to a worldwide pandemic.

Table 1
Cumulative confirmed human cases for avian influenza A(H5N1), 2003-2012

Country	Cases	Deaths	% Mortality
All Countries Reporting Outbreaks	607	358	59
Indonesia	190	158	83
Egypt	168	60	36
Vietnam	123	61	50
Three Combined	481	279	58

Source: WHO (2012)

However, the continuing circulation of the HPAI virus necessitates extensive surveillance—including viral culture—which is conducted in poultry markets, bird parks and in wild bird populations. There is need for continued biosecurtiy measures in poultry to prevent infection and the use of enhanced early warning systems to detect new cases of HPAI. This is due to the potential for mutations to create new strains of the virus, increasing the likelihood for person-to-person spread leading to a worldwide flu pandemic (Armbruster 2007). The 2009 H1N1 Swine Flu pandemic discussed earlier illustrates the human toll that could arise in the event of an H1N5 pandemic, especially given its high mortality rate to date.

Models show that it may be possible to identify a human outbreak at the earliest stage, when fewer than 100 cases exist, and deploy international resources such as a WHO stockpile of anti-viral drugs to rapidly quench it. This tipping point strategy would be highly cost effective. To implement such early intervention requires sound public health informatics, including state and local level collection and storage of vital statistics—birth and death records; collecting reports of communicable disease cases from doctors, hospitals, and laboratories to be used for infectious disease surveillance; sharing and disseminating of infectious disease statistics and trends; daily collection and analysis of emergency room data to detect early evidence of biological threats; and collection of hospital capacity information to allow for planning of responses in case of emergencies. Each of these activities is an information processing challenge of its own.

In addition to the potentially very large human toll from an H5N1 pandemic, there would also be large economic impacts. Oktaviani (2008) found that for Indonesia, the hardest hit of the SE Asian countries at the center of the mid-2000s HPAI outbreaks, a human pandemic from AI would decrease the country's GDP growth rate by approximately 0.5%, reflecting decreased investment and household income. There would be negative impacts on the poultry meat and egg sectors, even though that would not be the ongoing source of HPAI transmission. The psychological impact in the face of incomplete understanding of pandemic transmission would also likely impact the tourist, trade and transportation sectors.

Following a 2004 outbreak of HPAI in Japan and culling of many egg-laying hens, consumers demonstrated a willingness to substitute dried egg products—produced using virus-killing heat—for nondried egg products and fresh shell eggs—most likely to carry the HPAI virus (Taha and Hahn 2011). This was a large, temporary impact but showed the type of substitution to be expected in any future outbreaks of HPAI in a country. Once media reports help to educate consumers about the lack of transmission from the food products, the impact would be expected to be reversed over a period of time back to more normal consumption patterns.

The global nature of pandemics demands a concerted international response, if they are to be thwarted. Collaboration through information networks to guide international policy and protect human health is critical in a global economy. Controlling the spread of disease, developing identification systems and tracking approaches to trace animal diseases to the source of outbreak, and strengthening information sharing networks are all important strategies for controlling animal diseases. Information networks to protect human health rely on good information of highest integrity. Errors can destroy consumer confidence. Risk communication to maintain consumer trust is critical. Vigorous and effective information networks among scientists require that all work together (Armbruster 2007)

As one informatics tool to facilitate this critical international collaboration, WHO recently launched FluID—Flu Informed Decisions— as a global platform for data sharing that links regional influenza epidemiological data into a single global database. It provides connections between existing databases and can also be used to directly enter data through a web-based interface. It complements the existing virological data collection tool FluNet (WHO 2012). It also complements the existing worldwide surveillance and monitoring of animal diseases and disease control programs (Armbruster 2011)

The FluID platform accommodates both qualitative and quantitative data which facilitates the tracking of global trends, spread, intensity, and impact of influenza. These data are made freely available to health policy makers in order to assist them in making informed decisions regarding the management of influenza. Currently FluID is in an early rollout phase, only links with one regional database and allows countries to enter epidemiological data online directly. Global summary maps and charts will be made available as more countries and regions come online and submit data (WHO 2012). So, even though the incidences of H1N5 outbreaks have been quite few in recent years, health authorities worldwide are concerned enough about the potential for mutations to make the virus readily transmissible among humans to continue to devote significant resources to establish monitoring systems to allow early identification of such mutation and transmission. There is need for better information and understanding of the potential for mutations to occur which might make the flu readily transmissible among humans to create the ingredients for a devastating pandemic.

2. Research Controversy

Scientists have been conducting continuing research on HPAI to try to determine its mutation potential into a deadly, easily transmissible human disease since the initial outbreaks began. Two prominent research groups recently published research reports which caused quite a stir in scientific circles. One led by Ron Fouchier, at Erasmus MC in Rotterdam, the Netherlands was published by *Science* (Herfst 2012); and another by Yoshihiro Kawaoka of the University of Wisconsin, Madison and the University of Tokyo was published by *Nature* (Imai 2012). Both were released after a lengthy delay caused by concerns about the "dual-use research of concern (DURC)" nature of their findings. The concern was that that while the findings would be of significant value in furthering understanding of the HPAI virus and transmission potential that would be helpful to fellow scientists and policy makers working to assure that this virus does not evolve to cause a pandemic, it could also provide valuable information for those bent on microbiological terrorism (Alberts 2012).

Both of these research projects produced virus mutations capable of airborne transmission between ferrets the animal model of choice in influenza studies. The Kawaoka study created a hybrid virus which has not yet been found in nature and is likely to be more difficult to develop on its own. The Fouchier study started with an actual H5N1 virus isolated from a human victim in Indonesia. . The end result in each study was the creation of a mutation which could pass from one ferret to another through airborne droplets. More concerning was the small number of mutations needed to transform from the starting material into the human transmissible form. However, none of the ferrets succumbed from the contracted disease. So there is some good news to accompany the bad news news about transmissibility development (Enserink 2012). However, the Fouchier study shows that the A/H5N1 viruses can acquire the capacity for airborne transmission between mammals without recombination in an intermediate host and therefore constitute a risk for human pandemic influenza (Herfst, 2012). 1534).

The controversy originally delayed publication and the papers were submitted to the U.S. National Science Advisory Board for Biosecurity (NSABB) for evaluation. The NSABB originally recommended against publication, but in the end decided that publishing the reports was desirable because the findings demonstrated that H5N1 risks were real enough to justify sharing the data and findings so that other scientists could benefit in the ongoing important research to determine how to best keep the disease from becoming pandemic.(Enserink 2012). In the meantime, the Kawaoka and Fouchier labs collaborated on further research which found that as few as 3 additional amino acid substitutions in addition to 2 commonly occurring ones could create viruses which were readily transmissible via respiratory droplets between mammals. Their work also modeled within-host virus evolution to study factors affecting changes in probability of the remaining substitutions evolving after the virus infected a mammalian host. Their results highlight critical areas in which more data are need for assessing, and potentially averting , this threat (Russell 2012).

The parallel outcome of this controversy is that the boundaries of scientific freedom and its accompanying responsibilities of scientists are receiving increasing attention from the policy community and government regulators. The United States has adopted a new U.S. Policy for Oversight of Life Sciences Dual Use Research of Concern. On the surface, it seems like good news for scientists sharing the results and products of their research. However, the boundaries are less clear since the policy gives the U.S. government responsibility to consider risk mitigation strategies. Thus, the landscape of what dual-use life sciences research will look like in the U.S. and when it might be disseminated are open to boundary definition. The scientific community must be active participants in determining these boundaries, since they have a social responsibility to inform the scientific community, the general public and policy makers about any potential dangers of their work, as well as the risks and lost opportunities from restricting access to scientific information (Frankel 2012).

3. Concluding Observations and Implications

Concern continues to exist about possible development of easily transmissible viruses, especially the H5N1 HPAI virus, creating a worldwide pandemic. The 2009-2010 global influenza H1N1 pandemic led to a large number of deaths worldwide and to economic losses by pig producers and the pork processing and marketing sectors on a temporary basis. A number of lessons were learned in that pandemic which should help to minimize the chances of future such occurrences, including the need to effectively target Africa and Southeast Asia in infection prevention efforts. Further, continued surveillance and research is required to prevent pandemic HPAI outbreaks of potentially devastating scale. Early intervention, when it can be most effective, is dependent upon sound public health informatics. The global nature of pandemics necessitates concerted international response such as the recently launched global platform for sharing data through a single global database. Finally, care must be exercised by scientists to conduct themselves in ways that safeguard the public, yet allows sharing information among scientists, the public and policy makers.

Bibliography

Alberts, B. (2012): H5N1, in: Science 336, p. 1521

Armbruster, W. J. (2005): Mad Cows and Sick Chickens: Using Information Networks to Protect Human Health, in Proceedings of the 19th International Conference Informatics for Environmental Protection: Networking Environmental Information Part 2, Marsaryk University, Brno, Czech Republic

Armbruster, W.J. (2007): Animal Diseases and Human Health: Using Information Networks to Guide International Policy, presented in EnviroInfo 2007 Conference, Warsaw

Armbruster, W.J. (2011): Human and Animal Health Interactions: Computer Supported Communications Mitigate Pandemic Risks of Avian Influenza, presented in EnviroInfo 2011 Conference, Ispra, Italy

Attavanich, W., McCarl, B.A., Bessler, D. (2011): The Effect of H1N1 (Swine Flu) Media Coverage on Agricultural Commodity Markets, Applied Economics Perspectives and Policies, in: Applied Economic Perspectives and Policy 33(2), pp. 241-259

Dawood, F.S. (et al.) (2012): Estimated global mortality associated with the first 12 months of 2009 pandemic influenza A H1N1 virus circulation: a modelling study, The Lancet Infectious Diseases, Early Online Publication, 26 June 2012, doi:10.1016/S1473-3099(12)70121-4

Enserink, M. (2012): Public at Last, H5N1 Study Offers Insight into Virus's Possible Path to Pandemic, in: Science 336, pp. 1494-1497

Frankel. M.S. (2012): Regulating the Boundaries of Dual-Use Research, in: Science 336, pp. 1523-1525

Herfst, S. (2012): Airborne Transmission of Influenza A/H5N1 Virus between Ferrets, in: Science, 336, pp. 1534-1541

Imai, M. (2012): Experimental adaptation of an influenza H5 HA confers respiratory droplet transmission to a reassortant H5 HA/H1N1 virus in ferrets, in: Nature, 2 May 2012, 10.1038/nature10831

Oktaviani, R. (2008): The Impact of Avian Influenza (AI) on Poultry and Other Related Sectors on Indonesian Economy: A Recursive Dynamic CGE Approach, Presentation at 52nd Annual Conference of the Australian Agricultural and Resource Economics Society, Canberra, 8-10 February

Russell, C.A. (2012): The Potential for Respiratory Droplet-Transmissible A/H5N1 Influenza Virus to Evolve in a Mammalian Host, in: Science 336, pp. 1541-1547

Taha, F., Hahn, W. (2011): Avian Influenza Boosted Japan's Imports of Dried Egg Products, in: Amber Waves, 9(4), p. 5

World Health Organization (2012a): Cumulative number of confirmed human cases for avian influenza A(H5N1) reported to WHO, 2003-2012, http://www.who.int/influenza/human_animal_interface/EN_GIP_20120706CumulativeNumberH5N1cases.pdf

World Health Organization (2012b): FluID - a global influenza epidemiological data sharing, platformhttp://www.who.int/influenza/surveillance_monitoring/fluid/en/

A.4. Environmental and Sustainability Indicators: Case Study for Agriculture and Food Processing Sector (Hřebíček, J./Hodinka, M./Motyčka, A./Popelka, O./Trenz, O.)

Hřebíček, J./Hodinka, M./Motyčka, A./Popelka, O./Trenz, O. (2012): Environmental and Sustainability Indicators: Case Study for Agriculture and Food Processing Sector. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./ Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 83-93.

Environmental and Sustainability Indicators: Case Study for Agriculture and Food Processing Sector

Jiří Hřebíček[1], Michal Hodinka[1], Arnošt Motyčka[1], Ondřej Popelka[1],Oldřich Trenz[1]

Abstract

Current trends of environmental and sustainability indicators evaluation (i.e. measurement of environmental, social, economic and governance (ESG) performance) and corporate sustainability reporting are discussed in the paper focusing to agriculture and food processing sector. The relationship between environmental and sustainability indicators and corporate sustainability reporting is an important issue; and the development of advanced methods to identify key performance indicators towards sustainability indicators is discussed here along with the possibility of the utilization of information and communication technology and XBRL taxonomy.

1. Introduction

The team of Faculty of Business and Management (FBM) of Brno University of Technology (BUT) and Faculty of Business and Economics (FBE) of Mendel University in Brno (MENDELU) has solved the research project No P403/11/2085 "*Construction of Methods for Multi-factorial Assessment of Company Complex Performance in Selected Sectors*" since January 2011. The project is solved in 2011-2014 and funded by the Grant Agency of the Czech Republic. The main goal of the research in this project has been specified by Hřebíček et al., (2011, 2011a) and Chvátalová, Kocmanová and Dočekalová (2011).

The current trends of research in the area of corporate performance evaluation and corporate sustainability reporting in the Czech Republic was discussed by Hřebíček and Soukopová (2008), Hřebíček et al. (2009, 2011), Chvátalová, Kocmanová and Dočekalová (2011), Kocmanová et al. (2011), and Ritschelová et al. (2009). These papers reflect the overall global world trends of this area (Bassen/Kovacs 2008), (G3.1, 2011), (G4, 2012), (Schaltegger/Wagner 2006). Usually, organizations are monitoring, collecting and aggregating Environmental, Economical, Social and Governance (ESG) corporate data and information into *Key Performance Indicators* (KPIs) (Bassen/Kovacs 2008), (Garz/Schnella/Frank 2010), (Hřebíček et al., 2011a) which present *Corporate Sustainability Indicators*. This fact indirectly indicates that in the case of such needs the organization is able to aggregate these sets of data and incorporate them into the corporate sustainability or environmental report for public (Carroll, 1999), (Ritschelová et al., 2009), (Hodinka et al., 2012).

We have analyzed the collection of ESG data in chosen companies of the agriculture and food processing sector which have implemented and certified integrated management system standards, i.e. quality (ISO 9000), environmental (ISO 14000) and occupational health and safety (ISO 18000) management systems.

The corporate sustainability performance and its environmental and sustainability indicators would thus be defined by the integrated ESG performance measures. The sustainability performance is, however, often understood as performance in environmental, social and economic/financial indicators, thus excluding

[1] Faculty of Business and Economics, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic e-mail:{hrebicek,michal.hodinka,mot,ondrej.popelka,oldrich.trenz@mendelu.cz}, Internet: http://www.mendelu.cz

governance performance (Schaltegger/Wagner 2006). However, we will consider also the corporate governance like (Bhojraj/Sengupta 2003), (Kocmanová et al., 2011), to specify sustainability indicators.

In the paper we summarize the last results of project No P403/11/2085 of the analysis of ESG performance measures through corporate sustainability performance, its sustainability indicators and reporting for the agriculture and food processing sector. We issued from G3.1 Guidelines framework (G3.1, 2011) of the Global Reporting Initiative (GRI, 2012) which provides *Sector Supplement* for all reporting organizations in the *Food Processing* sector (Food Processing, 2012) and agri-environmental policy measures and indicators which have been implemented in the European Union (EU) (Bečvářová 2011), (Valtýniová/Křen, 2011), (Hřebíček et al., 2012), European Environment Agency (EEA, 2012) and Organisation for Economic Co-operation and Development (OECD) (Alkan Olsson et al., 2009), (OECD, 1997), (OECD, 2001), (OECD, 2008).

Our analyses of corporate performance measurements in chosen organizations of the agriculture and food processing sector by means specific KPIs were based on analyses of previous findings (Hřebíček et al., 2011, 2011a, 2012), (Chvátalová/Kocmanová/Dočekalová 2011), (Kocmanová/Dočekalová 2012) and will be summarized in the paper.

2. Sustainability indicators for Agriculture and Food Processing Sector

Let us consider sustainability indicators focus on companies within economic activity of NACE coding (NACE, 2011): *A – Agriculture, forestry and fishing* section, where we considered only subsections *01 – Crop and animal production, hunting and related service activities* excluding 01.07 (hunting, trapping and related service activities) and *C – Manufacturing section,* where we considered only subsections *10 – Manufacture of food products* excluding 10.9 (feed industry) and *11 – Manufacture of beverages*.

2.1 EU Agri-Environment Indicators

Before determination of sustainability indicators for investigated agriculture and food processing sector we had to consider and analyse the EU legislation, i.e. *Common Agriculture Politics* (CAP)[2] including the reporting needs of other EU policies that relate to *Agri-Environment Indicators* (EU AEI(s)) and requirements on the collection of related data.

The development of EU AEIs is a long-term project for monitoring the integration of environmental concerns into the CAP, proposed by the European Commission (EC) on 15 September 2006 in *COM (2006) 508 final "Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy"*. The EC adopted 28 EU AEIs to assess the interaction between the CAP and the environment. We took into account also the *COM (2000) 20 final "Indicators for the integration of environmental concerns into the common agricultural policy"*. In these Communications, the indicators are identified according to the *Driving forces – Pressures and benefits – State/Impact – Responses (DPSIR) analytical framework* and cover the following four categories: *Farm management practices; Agricultural production systems; Pressures and risks to the environment; The state of natural resources*.

In the context of the *Renewed EU Sustainable Development Strategy*[3], these EU AEIs serve to:

- provide information on the farmed environment;
- track the impact of agriculture on the environment;

[2] http://ec.europa.eu/agriculture/cap-post-2013/index_en.htm
[3] http://register.consilium.europa.eu/pdf/en/06/st10/st10917.en06.pdf

- assess the impact of agricultural and environmental policies on environmental management of farms;
- inform agricultural and environmental policy decisions;
- illustrate agri-environmental relationships to the broader public.

The last list of EU AEIs collected by Eurostat is summarized at Analytical framework[4] of its web page[5] devoted to EU AEIs track the integration of environmental concerns into the Common Agricultural Policy at EU, national and regional levels (Hřebíček et al., 2012).

However, the level of the development of these indicators with respect sustainability differs. Some EU AEIs are already operational, their concepts and measurement are well-defined and data are available at national and, where appropriate, at regional level. Other indicators are well-defined but they lack regional or harmonised data or their modelling approaches are weak. There are also indicators that still need substantial improvements in order to become fully operational. Therefore, not all indicators can be disseminated for the time being and we took this into account.

We were inspired by the development and progress in EU AEIs described in the series of Eurostat Methodologies & Working papers edited by Selenius, Baudouin and Kremer e.g. (Vinther et al., 2011) where are presented results of DireData project in the list of 32 EU AEIs confirmed by the EC.

2.2 OECD agri-environmental indicators

Agriculture has also significant impacts on the environment in OECD countries. The impacts occur on and off farm, including both pollution and degradation of soil, water and air, as well as the provision of ecological goods and services, such as biodiversity and providing a sink for greenhouse gases. To help improve measurement of the environmental performance of agriculture, OECD has established a set of agri-environmental indicators (OECD, 1997), (OECD, 2001), (OECD, 2008) with development of the indicators in cooperation with Eurostat and Food and Agriculture Organization of the United Nations (FAO)[6].

---

4 http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/introduction/analytical_framework

5 http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/introduction

6 http://www.fao.org/

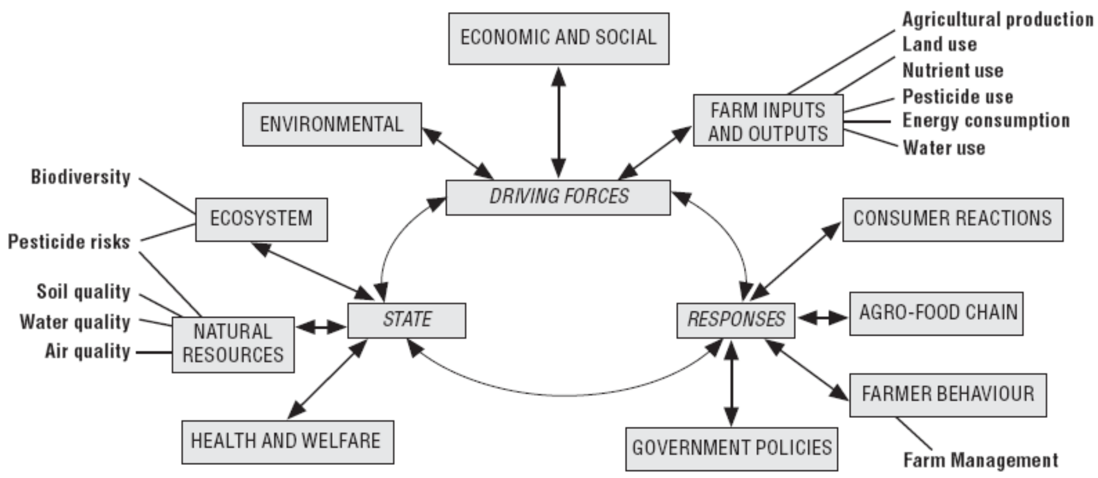

Figure 1
The OECD Driving Force-State-Response framework: Coverage of OECD AEIs
Source: (OECD, 2008, 23)

The set of OECD agri-environmental indicators (OECD AEIs)[7] has been developed through several specific theme focused workshops involving OECD country analysts and scientific experts, complemented with thorough reviews of the literature. The OECD's *Driving Force-State-Response* (DSR) *model* (Fig. 1) was the organising framework for developing the indicators (OECD, 1997), (OECD, 2008) instead of the EU DPSIR analytical framework.

The full list of 37 OECD AEIs was published in the chapter 1 of *Environmental Performance of Agriculture in OECD Countries Since 1990* (OECD, 2008) together with the assessment of these indicators according to the OECD indicator criteria - policy relevance, analytical soundness, measurability, and ease of interpretation. Other *OECD AEIs*[8] for which either methodologies and/or data sets are not yet at a stage that allows for representative comparative OECD country coverage or in certain cases (e.g. cultural landscape indicators and water retaining capacity) are only policy-relevant to some OECD countries.

OECD fosters sustainable development by using indicators to analyse and measure the effects on the environment of domestic agricultural and agri-environmental policies and trade measures. OECD trends of environmental and sustainability conditions related to agriculture are examined across nine themes since 1990 (OECD, 2008):

1. Agricultural production and land.
2. Nutrients (nitrogen and phosphorus balances).
3. Pesticides (use and risks).
4. Energy (direct on-farm consumption).
5. Soil (water and wind erosion).
6. Water (use and quality).
7. Air (ammonia, methyl bromide use, greenhouse gas emissions).
8. Biodiversity (genetic, wild species and ecosystem diversity).
9. Farm management (nutrients, pests, soil, water, biodiversity and organic).

---

[7] http://www.oecd.org/dataoecd/46/39/40673091.pdf
[8] http://www.oecd.org/dataoecd/46/38/40673129.pdf

2.4 EEA Environmental Indicators

Over the past two decades, the European Environment Agency (EEA) has published assessments and indicators on most European environmental issues. Today it maintains an extensive set of over 200 environmental indicators[9] across 12 environmental themes (EEA, 2012), which are: *Agriculture; Air pollution; Biodiversity; Climate change; Energy; Transport; Waste; Water; Fisheries; Land and soil; Tourism; Environmental scenarios.* EEA indicators are developed against the DPSIR assessment framework.

Simply put, following the DPSIR framework, social and economic developments drive (D) changes that exert pressure (P) on the environment. As a consequence, changes occur in the state (S) of the environment, which lead to impacts (I) on, for example, human health, ecosystem functioning and the economy. Finally societal and political responses (R) affect earlier parts of the system directly or indirectly.

EEA has developed a formidable store cupboard of environmental, economic and social data and indicators that could be used to a much greater degree than hitherto, to support current policy priorities such as the Europe 2020 strategy and the forthcoming 7th Environmental Action Programme. The EEA aims to deliver timely, targeted, relevant and reliable information to policymakers and the public – environmental indicators play a key role in this. We have considered the Core Set of Indicators (CSI) published at (EEA 2012), particularly indicators on "Gross nutrient balance" (CSI 25) and "Area under organic farming" (CSI 26) which illustrate progress to low-input agriculture in a green economy.

2.4 GRI Guidelines for Food Processing Sector

In March 2011, the GRI released the G3.1 Guidelines (G3.1, 2011), an update and completion of the GRI G3 Guidelines from 2006, which consist of two parts. The part 1 of G3.1 Guidelines features guidance on how to report. The part 2 of G3.1 Guidelines features guidance on what should be reported, in the form of *Disclosures on Management Approach* (DMA) and *Performance Indicators* (PI), which are organized into categories: *Economic, Environmental and Social*. The Social category is broken down further by *Labour, Human Rights, Society* and *Product Responsibility* subcategories. Each category includes a DMA and a corresponding set of *Core* and *Additional Performance Indicators*.

Core Performance Indicators (CPI) have been developed through GRI's multi-stakeholder processes, which are intended to identify generally applicable PIs and are assumed to be guide for most organizations. An organization should report on CPIs unless they are deemed not guidance on the basis of the GRI Reporting Principles. Further, we will take into account that CPIs can be in a compliance with Key Performance Indicators (KPIs) and we will use CPIs of GRI as a standard used in computation of KPIs for determination of Sustainability indicators.

Additional Performance Indicators (API) of GRI represent emerging practice or address topics that may be a guide for some organizations, but are not material for others. Further we will not take into account APIs and try to indentify only CPIs respectively KPIs.

The *Disclosures on Management Approach* should provide a brief overview of the organization's management approach to the *Aspects* defined under each *Indicator Category* in order to set the context for performance information (G3.1, 2011). The organization can structure its DMA to cover the full range of Aspects under a given Category or group its responses on the Aspects differently. However, the DMA should address all of the Aspects associated with each category regardless of the format or grouping.

Although the G3.1 Guidelines have served as an essential and very useful tools in improving the standardization of organization's reporting in many sectors, organizations continue to have differing degrees of compliance with the G3.1 Guidelines and sometimes also differing views on the best tools to apply

[9] http://www.eea.europa.eu/data-and-maps/indicators

these standards to their reporting and determination of the set of sustainability indicators. We will make this also for sustainability indicators of agriculture and food processing sector.

The integration of financial performance and economic indicators within environmental, social and governance performance and indicators reflects a growing desire by stakeholders for more information on a broader range of issues. To be comparable across all organizations, and thus useful for mainstream investment analyses, it is important that financial/economic, environmental, social and governance (ESG) data are transformed into consistent units and presented in a balanced and coherent manner in KPIs indicators (Garz/Schnella/Frank 2010).

G4 Guidelines of GRI is coming in GRI's fourth generation of *Sustainability Reporting Guidelines* and they are now in development (G4, 2012), where is prepared a redesign of the G4 Guidelines format (by separating "standard like" requests from guidance, making it web based, offering templates, linking it to technology solutions with using XBRL taxonomy (Hodinka et al., 2012), (XBRL, 2012)).

We used ideas and methodology of the *Food Processing Sector Supplement* (FPSS) (Food Processing, 2012) of GRI Guidelines for development sustainability indicators. The FPSS includes the original GRI Guidelines, which set out the Reporting Principles, Disclosures on Management Approach and Performance Indicators for economic, environmental and social issues. Sector-specific categories on Sourcing and Animal Welfare are included also for the food processing sector.

GRI provides a table mapping G3.1 to the Food Processing Supplement to help find the changes that the G3.1 updates bring to this Supplement.

2.5 ICT support of reporting environmental and sustainability indicators

GRI has launched a new XBRL taxonomy for tagging sustainability data in reports, making it easier for report users – including regulators, investors and analysts – to find and analyze data. GRI taxonomy will enable companies and other organizations to use XBRL (XBRL, 2012) to improve their sustainability reporting and make the data in their reports more accessible. Nelmara Arbex, Deputy Chief Executive of the GRI, said: "*Today's new taxonomy is a major step forward in making sustainability data available to society. Many companies already use XBRL to tag their financial performance data; the GRI Taxonomy means that companies can tag their sustainability data, making it easily accessible for people who want to find information in the report*."

We are going to develop ICT tools in the project No P403/11/2085 for computation and evaluation of chosen environmental and sustainability indicators at Agriculture and Food Processing sectors (Hřebíček at al., 2012) and use these in corporate sustainability reporting (Hodinka et al., 2012). In this case, we would deal with creation of an application supported by XBRL format used for a data input. The input data would possess the form of a company report considering the agriculture and food processing sector.

3. Determination of sustainability indicators

The creation of reliable methods of sustainability (economic, environmental and social) indicators at agriculture and food processing sector where concurrent acting of multiple factors is in play can be considered a prerequisite for success not only in decision-making, but also with regard to corporate governance, comparison possibilities, development of a healthy competition environment etc.

3.1 Integration of economic indicators to sustainability indicators set

The economic dimension of sustainability concerns the organization's impacts on the economic conditions of its stakeholders and on economic systems at local, national, and global levels. The economic indicators illustrate flow of capital among different stakeholders; and main economic impacts of the organization throughout society. Economical performance indicators are often used for selection strategies (maximizing profits, maximizing total costs, company survival, etc.) based on direct economic impacts of customers, suppliers, employees, providers of capital, public etc.

Financial performance is fundamental to understanding an organization and its own sustainability. However, this information is normally already reported in financial accounts. What is often reported less, and is frequently desired by users of sustainability reports, is the organization's contribution to the sustainability of a larger economic system.

We took into account GRI's Reporting Guidelines FPSS and choose following economic KPIs also connected with Agriculture (Kocmanová, Dočekalová, 2012):

1. EC1 – Direct economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments.
2. EC4 – Significant financial assistance received from government.

We have used our developed ICT tools based on the abovementioned XBRL taxonomy to facilitate the calculations and the visualizations of above mentioned chosen economical performance indicators (Hodinka et al., 2012).

3.2 Integration of agri-environmental and environmental indicators to sustainability indicators set

The environmental dimension of sustainability concerns an organization's impacts on living and non-living natural systems, including ecosystems, land, air, and water. Environmental indicators cover performance related to inputs (e.g., material, energy, water) and outputs (e.g., emissions, effluents, waste). In addition, they cover performance related to biodiversity, environmental compliance, and other relevant information such as environmental expenditure and the impacts of products and services. We have determined KPIs for environmental reporting using results of our previous research in this field (Hřebíček et al., 2011, 2012), using the G3.1 Guideline notation (GRI 3.1, 2011), EMAS indicators (EMAS III, 2009), which were accepted by the Ministry of Environment of the Czech Republic as its official methodology for environmental reporting, further chosen EU AEIs (Vinther, et al. 2011) and OECD AEIs (OECD, 2008) and finally CSI for agriculture (EEA, 2012).

The proposed KPIs shall apply to all organizations in all economic activity sectors including agriculture and food processing sectors:

1. Efficiency of material consumption, where are used EN1 and EN2 indicators from (GRI 3.1, 2011);
2. Energy efficiency, where are used EN3, EN4 indicators from (GRI 3.1, 2011);
3. Water management, where is used EN8 indicator from (GRI 3.1, 2011);
4. Waste management, where we used EN22 indicator from (GRI 3.1, 2011);
5. Biodiversity, where are used EN12 and EN13 indicators from (GRI 3.1, 2011);
6. Air pollution, where are used EN16, EN17, EN19, EN20, EN21, EN23 indicators from (GRI 3.1, 2011);

3.3 Integration of social indicators to sustainability indicators set

The social dimension of sustainability concerns the impacts for company that has on the social systems within which it operates. We are going to determine KPIs for social performance based on the GRI social performance indicators to identify key performance aspects surrounding labor practices, human rights, society, and product responsibility (Hřebíček et al., 2011), (G3.1, 2011), (Food Processing, 2011) and in the following key areas:

1. Labor Practices and Decent Work indicators are broadly based on the concept of decent work. The set begins with disclosures on the scope and diversity of the reporting organization's workforce, emphasizing aspects of gender and age distribution. We here take into account following KPIs:
   - Employment – LA1 and LA3 indicators from FPSS;
   - Labour/management relations – LA4, LA5 and FP3 (Percentage of working time lost due to industrial disputes, strikes and/or lock-outs, by country) indicators from FPSS;
   - Occupational Health and Safety – LA7, LA8 indicators from FPSS;
   - Training and Education – LA10 indicator from FPSS;
   - Diversity and Equal Opportunity – LA13 and LA14 indicators from FPSS;
2. Human Rights indicators require companies to report on the extent to which human rights are considered in investment and supplier/contractor selection practices. We here take into account:
   - Investment and procurement practices – HR1 and HR2 indicators from FPSS;
   - Non-discrimination – HR4 indicator from FPSS;
   - Freedom of association and collective bargaining – HR5 indicator from FPSS;
   - Child labour – HR6 indicator from FPSS;
   - Forced and compulsory labour – HR7 indicator from FPSS;
3. Society indicators focus the attention on the impacts organizations have on the communities in which they operate, and disclosing how the risks that may arise from interactions with other social institutions are managed and mediated. In particular, information on the risks associated with bribery and corruption is sought, as well as information on the undue influence in public policy-making, and monopoly practices. We here take into account:
   - Local community – SO1 and FP4 (Nature, scope and effectiveness of any programs and practices (in-kind contributions, volunteer initiatives, knowledge transfer, partnerships and product development) that promote healthy lifestyles; the prevention of chronic disease; access to healthy, nutritious and affordable food; and improved welfare for communities in need) indicators from FPSS;
   - Corruption – SO2, SO3 and SO4 indicators from FPSS;
   - Public policy – SO5 and SO6 indicators from FPSS.
4. Product responsibility indicators address the aspects of a reporting organization's products and services that directly affect customers. We take into account namely:
   - Customer Health and Safety – PR1, FP5 (Percentage of production volume manufactured in sites certified by an independent third party according to internationally recognized food safety management system standards), FP6 (Percentage of total sales volume of consumer products, by product category, that are lowered in saturated fat, trans fats, sodium and sugars) and FP7 (Percentage of total sales volume of consumer products, by product category sold, that contain increased fiber, vitamins, minerals, phytochemicals or functional food additives) indicators from FPSS;
   - Products and Services Labelling – PR3, and FP8 (Policies and practices on communication to consumers about ingredients and nutritional information beyond legal requirements) indicators from FPSS.

The integration process of the development of the complete set of social performance indicators is in progress and the final version of KPIs is planned to be complete, as a part of our research project, towards the end of this year.

3.4 Integration of corporate governance indicators to sustainability indicators set

We have analyzed the corporate governance performance of organizations of agriculture and food processing sector vis-à-vis clear and transparent management principles: efforts for clarification and transparency; level of clarification of stakeholders; transparency of stakeholders.

We are going to propose corporate governance indicators that cover the exercise of leadership: direct participation by CEO; communication with employees; communication from employees.

We also consider further corporate governance indicators that could cover, as far as management systems are concerned:

1. Functional powers of board of directors and board of auditors (or auditors) in: participation in real discussion; integration of external perspectives; opinions of auditors/board of auditors; support given to auditors.
2. Appointment and assessment of CEO in: appointment; assessment and removal; decisions on remuneration.

Within the context of the organization's management as an effective decision-making authority for global organizations, we have developed an approach to reviewing the corporate governance effectiveness that we have structured this around three areas of risk and underperformance.

4. Conclusions

The presented paper has introduced chosen results of the project No P403/11/2085 funded by the Czech Science Foundation There were presented the results of the analysis of the state-of-art on agri-environmental and sustainability indicators at Agriculture and Food Processing Sector and their integration to corporate sustainability reporting with XBRL taxonomy.

Acknowledgment

This paper is supported by the Czech Science Foundation. Name of the Project: Construction of Methods for Multifactor Assessment of Company Complex Performance in Selected Sectors. Registration No P403/11/2085.

Bibliography

Alkan Olsson, J. (et al) (2009): A goal oriented indicator framework to support integrated assessment of new policies for agri-environmental systems, in: Environmental Science & Policy No. 12, pp. 562–572.

Bassen, A., Kovacs, A. M. (2008): Environmental, Social and Governance Key Performance Indicators from a Capital Market Perspective, in: Zeitschrift für Wirtschafts und Unternehmensethik, No.9, pp. 182–192.

Bevářová, V. (2011): The European Model of Agricultural Policy in the Global Context. In: New Knowledge in a New Era of Globalization, Edited by Piotr Pachura. economia. Rijeka, Croatia: InTech Open, 285–310.

Bhojraj, S., Sengupta, P. (2003): The Effect of Corporate Governance Mechanisms on Bond Ratings and Yields: The Role of Institutional Investors and Outside Directors, in: Journal of Business, No. 3, pp. 455–475.

Carroll, A. B. (1999): Corporate Social Responsibility: Evolution of a Definitional Construct, in: Business & Society, No. 3, pp. 268–295.

EEA (2012): Environmental Indicators Report 2012. Available:

Food Processing (2012): Available: https://www.globalreporting.org/reporting/sector-guidance/food-processing/Pages/default.aspx.

Garz, H., Schnella, F. Frank, R. (2010): KPIs for ESG. A Guideline for the Integration of ESG into Financial Analysis and Corporate Validation. Version 3.0, Frankfurt, DVFA/EFFAS, Available: http://www.dvfa.de/files/die_dvfa/kommissionen/non_financials/application/pdf/KPIs_ESG_FINAL.pdf.

GRI (2012): Global Reporting Initiative. Available: http://www.globalreporting.org.

G3.1 (2011): G3.1 Guidelines. Available: http://www.globalreporting.org/ReportingFramework/G31Guidelines.

G4 (2012): G4 Development. Available: https://www.globalreporting.org/resourcelibrary/G4-PCP1-Full-Report.pdf.

Hodinka, M. (et al) (2012): Current trends of corporate performance reporting tools and methodology design of multifactor measurement of company overall performance. In: Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, No. 2, pp. 85–90.

Hřebíček, J. Soukopová, J. (2008): Voluntary Company Assessment Report on the linkages between environment, economy and society (in Czech). Praha: Ministry of Environment of the Czech Republic.

Hřebíček, J. (et al) (2009): Current Trends in Sustaina bility Reporting in the Czech Republic, Proceedings of EnviroInfo 2009. Environmental Informatics and Industrial Environmental Protection: Concepts, Methods and Tools. 23. International Conference on Informatics for Environmental Protection, Aachen: Shaker Verlag, 233–240.

Hřebíček, J. (et al) (2011): Corporate Key Performance Indicators for Environmental Management and Reporting. in: Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, No, 2, 99–108.

Hřebíček, J. (et, al.) (2011a): Integration of Economic, Environmental, Social and Corporate Governance Performance and Reporting in Enterprises. In: Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, No. 7. 157–177.

Hřebíček, J. (et, al.) (2012): Corporate performance indicators for agriculture and food processing sector. in: Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, No. 4, pp. 121–132.

Chvátalová, Z., Kocmanová, A., Dočekalová, M. (2011): Corporate Sustainability Reporting and Measuring Corporate Performance, Proceedings of Environmental Software Systems. Frameworks of eEnvironment. 9th IFIP WG 5.11 International Symposium. ISESS 2011. Heidelberg: Springer, 398–406.

Kocmanová, A. (et al) (2011): Sustainability: Environmental, Social and Corporate Governance Performance in Czech SMEs. In: The 15th World Multi-Conference on Systemics, Cybernetics and Informatics. IFSR, Orlando, USA: WMSCI 94–99.

Kocmanová, A., Dočekalová, M. (2012): Construction of the economic indicators of performance in relation to environmental, social and corporate governance (ESG) factors. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, No. 4, pp. 195–206.

NACE (2011): List of NACE codes. Available http://ec.europa.eu/competition/mergers/cases/index/nace_all.html.

OECD (1997): Environmental Indicators for Agriculture Volume 1: Concepts and Frameworks, Paris, France, Available: http://www.oecd.org/tad/env/indicators.

OECD (2006): Environment at a Glance:OECD Environmental Indicators 2005, Paris, France, Available: http://www.oecd.org/env.

OECD (2008): Environmental Performance of Agriculture in OECD Countries Since 1990. Paris, France, Available: http://www.oecd.org/env.

Ritschelová, I. (et, al.) (2009): Corporate Environmental Reporting in the Czech Republic and its Relation to Environmental Accounting at Macro Level. In: 11th Annual EMAN Conference on Sustainability and Corporate Responsibility Accounting. Measuring and Managing Business Benefits. Budapest: AULA, 55–60.

Vinther, F.P. (et al) (2011): Data requirements, availability and gaps in Agri-environment indicators (AEIs). Selenius, J., Baudouin, L. Kremer, A. M. Eurostat Methodologies and Working papers. Luxembourg, Publications Office of the European Union, Available: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-11-022/EN/KS-RA-11-022-EN.PDF.

Schaltegger, S., Wagner, M. (2006): Integrative Management of Sustainability Performance, Measurement and Reporting.in: International Journal of Accounting, Auditing and Performance Evaluation. No.3, pp.1–19.

Valtýniová, S., Křen, J. (2011): Indicators used for assessment of the ecological dimension of sustainable arable farming – review, in: Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, LIX, No. 3, pp. 247–256.

XBRL (2012): An Introduction to XBRL. Available: http://www.xbrl.org/WhatIsXBRL.

A.5. Annotation of Environmental and Epidemiological Systems: TaToo case study (Kubásek, M./Hřebíček, J./Kalina, J.)

Kubásek, M./Hřebíček, J./Kalina, J. (2012): Annotation of Environmental and Epidemiological Systems: TaToo case study. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 95-102.

Annotation of Environmental and Epidemiological Systems: TaToo case study

Miroslav Kubásek[1], Jiří Hřebíček[1], Jiří Kalina[1]

Abstract

The synthesis of existing Persistent Organic Pollutants pollution monitoring databases with epidemiological data is considered for identifying some impacts of Persistent Organic Pollutants on human health. This task requires new, rich, data, services and models discovery capabilities from a multitude of monitoring networks and web resources. The FP7 project TaToo (Tagging Tool based on a Semantic Discovery Framework) is setting up a semantic web solution to close the discovery gap that prevents a full and easy access to web resources. The use of TaToo tools together with the Global Environmental Assessment and Information System and the System for Visualizing of Oncological Data is discussed as TaToo validation scenario for anthropogenic impact and global climate change influence on Persistent Organic Pollutants trajectory.

1. Introduction

Persistent organic pollutants (POPs) represent a long-term problem which is connected with the production, application, and disposal of many hazardous chemicals and their impacts on human health. The Research Centre for Toxic Compounds in the Environment (RECETOX) of the Masaryk University (MU) is focused on the research of the fate and biological effects of POPs and other toxic substances in the environment. RECETOX monitors these chemicals in air, soil, water or human milk, and supports the implementation of international conventions on chemical substances like the *Stockholm Convention on Persistent Organic Pollutants*[2] (Klánová et al., 2009).

RECETOX closely cooperates with the Institute of Biostatistics and Analyses (IBA) of MU. IBA is a research institute oriented to the solution of scientific projects and providing related services, especially in the field of environmental, biological and clinical data analysis. IBA created the *System for Visualizing of Oncological Data* (SVOD)[3] – web portal of epidemiology of malignant tumours in the Czech Republic (Dušek et al., 2005), which is based on the data from the Czech National Oncology Register.

Specific effects of POPs can include cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system. Some POPs are also considered to be endocrine disrupters, which, by altering the hormonal system, can damage the reproductive and immune systems of exposed individuals as well as their offspring; they can also have developmental and carcinogenic effects.

In January 2010 RECETOX launched the first version of the *Global Environmental Assessment and Information System* (GENASIS)[4] – web portal which provides information support for implementation of the Stockholm Convention at international level (Urbánek et al., 2010). Initial phase of the GENASIS is fo-

[1] Masaryk University, Institute Biostatistics and Analyses, Kamenice 126/3, 62500 Brno, Czech Republic {kubasek, hrebicek, kalina}@iba.muni.cz

[2] Stockholm Convention on Persistent Organic Pollutants, http://chm.pops.int/

[3] http://www.svod.cz - System for Visualizing of Oncological Data, http://www.svod.cz/?sec=aktuality&lang=en

[4] http://www.genasis.cz - Global Environmental Assessment and Information System, http://www.genasis.cz/main-index/en/

cused on data from regular POPs monitoring programmes, providing a general overview of spatial patterns and temporal trends of pollutants concentrations. The aim is now to try to find out whether there is a connection between the concentration of POPs and cancer occurrence in some regions.

This task requires new discovery information and communication technology (ICT) tools which will be developed within the FP7 project *Tagging Tool based on a Semantic Discovery Framework* (TaToo)[5] (Rizzoli et al., 2010) and shared the vision of a *Single Information Space in Europe for the Environment* (SISE) (Hřebíček/Pillmann, 2010), (Pillmann/Hřebíček 2011), It aims to develop tools allowing third parties to easily discover web resources (data, services and models) and to add valuable information on to these resources. TaToo tools will be validated in three different validation scenarios. MU is solving the TaToo validation scenario of *Anthropogenic impact and global climate change*. It aims to improve the discovery of web resources in the domains of environmental pollution by POPs including influence of global climate change and epidemiology and tries to find relationships between these domains.

2. Scenario description

GENASIS is a part of the validation scenario "Anthropogenic impact and global climate change" (abbreviated "MU Scenario") of the FP7 project TaToo. The validation scenario is led by MU and focused on the correlation of environmental pollutants (POPs) and their impact on health of human population and also included an impact of global climate change on an atmospheric transport of POPs. The development of a set of TaToo tools will provide a preliminary semantic analysis of the content of web resources for the MU Scenario, with the ability to access different published ontologies that describe the available knowledge basis. The aim of MU Scenario is to create a central place for researchers, domain experts and decision makers to discover and access interdisciplinary knowledge in a more efficient and usable way that is the current state of the art (Hřebíček et al., 2010, 2010a).

The MU Scenario is not limited to the use of TaToo tools in order to improve the discovery of scientific resources for one particular domain, but also tries to discover and create new relationships among different domains (environmental pollution and cancer epidemiology). The correlation of POPs, including their transport due to global climate change and their impact on the health of human population, is only one significant example of creating new relationships among different domains. These correlations could represent new scientific insights into already available resources and connect the knowledge of the single domains. These relationships should facilitate further discovery process to deliver matching resources of multiple domains.

The objective of the MU scenario is to use and validate the resulting tagging and discovery framework of the TaToo project. Since the primary scope of the TaToo project is to facilitate the discovery of environmental resources, this scenario delivers the perfect opportunity to validate the resulting solution against challenging real word problems. There are numerous scientific domains available and actively researched at the MU, but two important domains have been carefully chosen to demonstrate and validate the envisioned functionality of the TaToo project. The vision of the MU scenario is that other scientific domains could follow the initial institutes to further spin a new kind of knowledge network to deliver a new generation of tools and methods to effectively and conveniently support the scientific user in their daily work.

3. Domain ontology

The objectives of the TaToo project at semantic tagging and searching environmental resources are based on the principles of the Semantic Web using ontologies as the underlying model for tagging and searching

[5] Tagging Tool based on a Semantic Discovery Framework, http://www.tatoo-fp7.eu/tatooweb/

resources. The main objective of the ontologies within the TaToo project Framework is to allow formal and contextual cross-domain tagging of searched environmental resources. Within the process of ontology development, we kept existing W3C standards, particularly RDF, RDFS and OWL, in particular a subset of OWL 2 called OWL2 RL. Within TaToo project, the use of the NeOn methodology has been fostered , (Pariente et al., 2011). As regards the specification of ontologies, we have used current tools for ontology engineering, such as the NeOn-Toolkit or Protégé.

3.1 MU domain ontology

By analyzing of both domains, i.e. environmental and human risk assessment areas we proposed initial version of ontologies. For modelling ontology we uses *Web Ontology Language* (OWL)[6] and NeOn Toolkit[7]. Our proposed ontologies contain 351 concepts. In our ontologies we have identified four levels of concepts in structure of ontologies (Kubásek et al., 2011), (Hřebíček et al., 2012).

The first one named **nomenclature** contains a set of nominal descriptors identifying key objects (variables) which should be mostly identified in investigation or in research searching for information (POPs – chemical compounds and diseases – cancer diagnoses). This level is highly standardized adopting internationally unified, extensively translated nomenclature systems. The proposed framework works with key (major) nomenclature system and additional (supporting) sub-systems. Proposed ontology architecture is relatively rigid in this dimension as the used nomenclature systems are based of widely accepted international consensus. In proposed version of ontology we used ICD-10 class hierarchy (International Classification of Diseases) and recommended POPs and Matrix taxonomy based on Stockholm Convention.

The second level is **classifiers** which present a attributes determining some key properties of the examined objects (chemical compounds, diseases). Only classifiers highly relevant for exposure environmental studies and risk assessment studies are adopted. In result, the classifiers represent binary codes or multiple categories, typically derived on the basis of some external information reachable from standardized database, evidence-based literature, thesaurus or encyclopedia (properties of given chemical compounds, properties of disease at the time of diagnosis, etc.). The set of attributes is flexible according of used classifiers; e.g. In case of studies focusing on some special topics etc. This level is included in the proposed ontology.

Next level is **information source identifiers -** necessary descriptors of the source of information which is processed or needed. These attributes also refer to some type of validity scoring because they describe type of studies and other information sources which can be regarded as relevant. Furthermore, this set of attributes allows the users to specify studied problem or scientific field to be inspected.

Last level contains **obligatory descriptors** which represent family of variables describing the lowest level of the information processed or searched for. It means set of variables which are obligatory to understand numerical values reached in searching engines (units, sampled, matrices, epidemiological measures, time and site specification, etc.). These descriptors are strictly obligatory and represent valid information, i.e. only information, numerical value supplied with these descriptors can be regarded as valid and trustworthy.

3.2 MU domain ontology alignment

The Bridge Ontology within TaToo ontology framework is provided in order to ensure the interoperability between the different ontologies. Mappings between the Domain Ontologies and the Bridge are needed to

[6] http://en.wikipedia.org/wiki/Web_Ontology_Language
[7] http://neon-toolkit.org

ensure this interoperability. Therefore a second ontology that imports both Bridge and Domain Ontologies and contains alignments between concepts of Domain and Bridge Ontologies are in need to be defined. Aligning the Domain Ontology of our validation scenario to MERM comprises three tasks (Hřebíček et al., 2012):

- The resource types will be classified under merm:Annotation class.
- The classes to be annotated with the resources will be classified under bridge:Topic class.
- The ontology specific tagging relationships will be classified under merm:subject property.

In the end all these classes and properties will be either sub- or equivalent taxonomies of the MERM ontology in order to operate with the platform. Some taxonomies, if believed necessary, can be linked with the specific subclasses of Annotation and Topic classes or sub properties of the subject property.

4. Mapping onto the TaToo framework

The main entry point of the TaToo Framework Architecture for accessing tags and annotations of environmental resources is the TaToo Web Portal and TaToo Web Services, which both provide access to the TaToo repository. The TaToo Web Portal is built on Liferay Portal which is an implementation of JSR-286 enterprise portal. TaToo Web Services include a set of services based on the SOAP and WSDL standards, and the TaToo repository is build on Sesame framework - a de-facto standard framework for processing RDF data which fully supports the SPARQL query language for expressive querying.

We developed MU Specialized Tagging Portlet in GENASIS (Hřebíček et al., 2012). This portlet is a part of the TaToo Web Portal and provides domain-specific tagging functionality. It supports a variety of meta-information schemes based on a very generic user interface, and is designed for tagging and annotating a specific set of domain-related resource types with POPs and other related concepts from the Domain Ontology of MU Scenario.

The Discovery Component of TaToo acts as a Web Client of the TaToo Discovery Web Service for GENASIS and is also able to display the retrieved information in an appropriate manner. It will become a part of current analytical tools of GENASIS.

The Discovery Component of TaToo is designed to discover and visualize POPs and related resources and thus is focused on a set of predefined topics from the MU Domain Ontology.

4.1 Managing domain resources

The primary goal of the SVOD/GENASIS Harvester Connector is to populate the TaToo Knowledgebase with resources offered by the Validation Scenario. These resources encompass for example analysis and scientific reports generated by the SVOD/GENASIS web portals. The harvested resources of the Validation Scenario can then take part in the information enrichment process as it has been described in the Use Case mentioned above.

For making possible the harvesting process MU provided a "Resource Catalogue"[8], which contains all possible resources from MU domains (both POPs and cancer). This catalogue enables our administrators to manage resources (edit basic resource attributes and keep them up-to date) and also manages topics from our Domain Ontology connected to these resources. This catalogue also provides RDF for all resources to enable the harvesting process. In *Figure 1:* you can see the screenshot of this tool.

[8] Available on http://ontology.genasis.cz

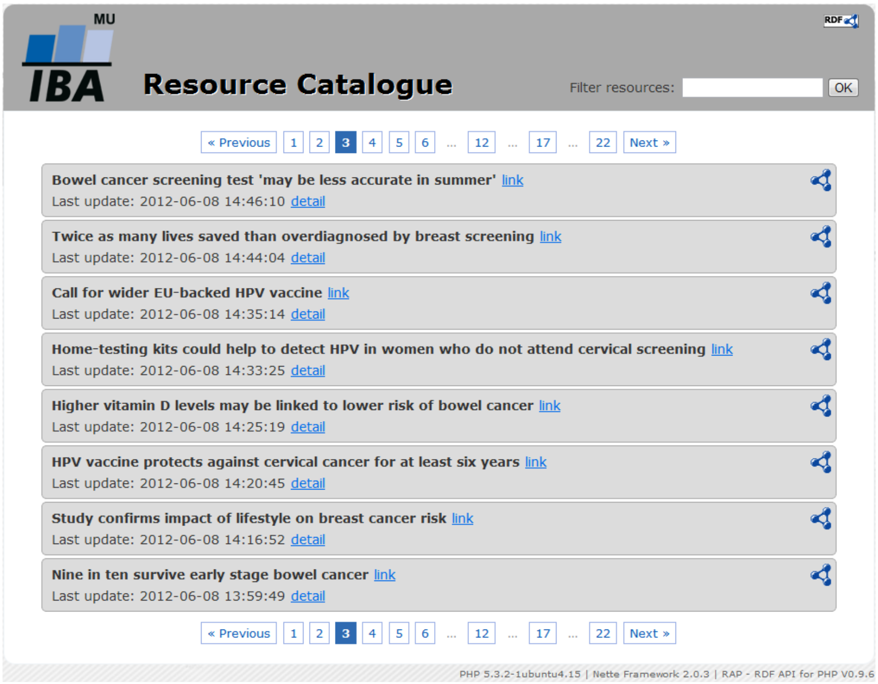

Figure 1
GUI of Resource Catalogue

4.2 Discover resources with existing tools

Purpose of this case study is to provide the users of SVOD and GENASIS portals with the possibility to indirectly use the TaToo functionality for the discovery of similar resources based on analysed objects. The TaToo discovery is started directly from within the web analysis tools. The relevant information needed for the search would be already entered via the web interface during the analysis and can be submitted to the TaToo framework.

In this case study we implemented simply "TaToo button" into SVOD and GENASIS analyse tools and applied TaToo Discovery Service to retrieve a list of related data resources from TaToo Repository (See Figure 2). Queries used in calling the Discovery Service are automatically built from actual settings of analytics tools. Communication between TaToo Discovery Service and developed discovery application is based on SOAP standard.

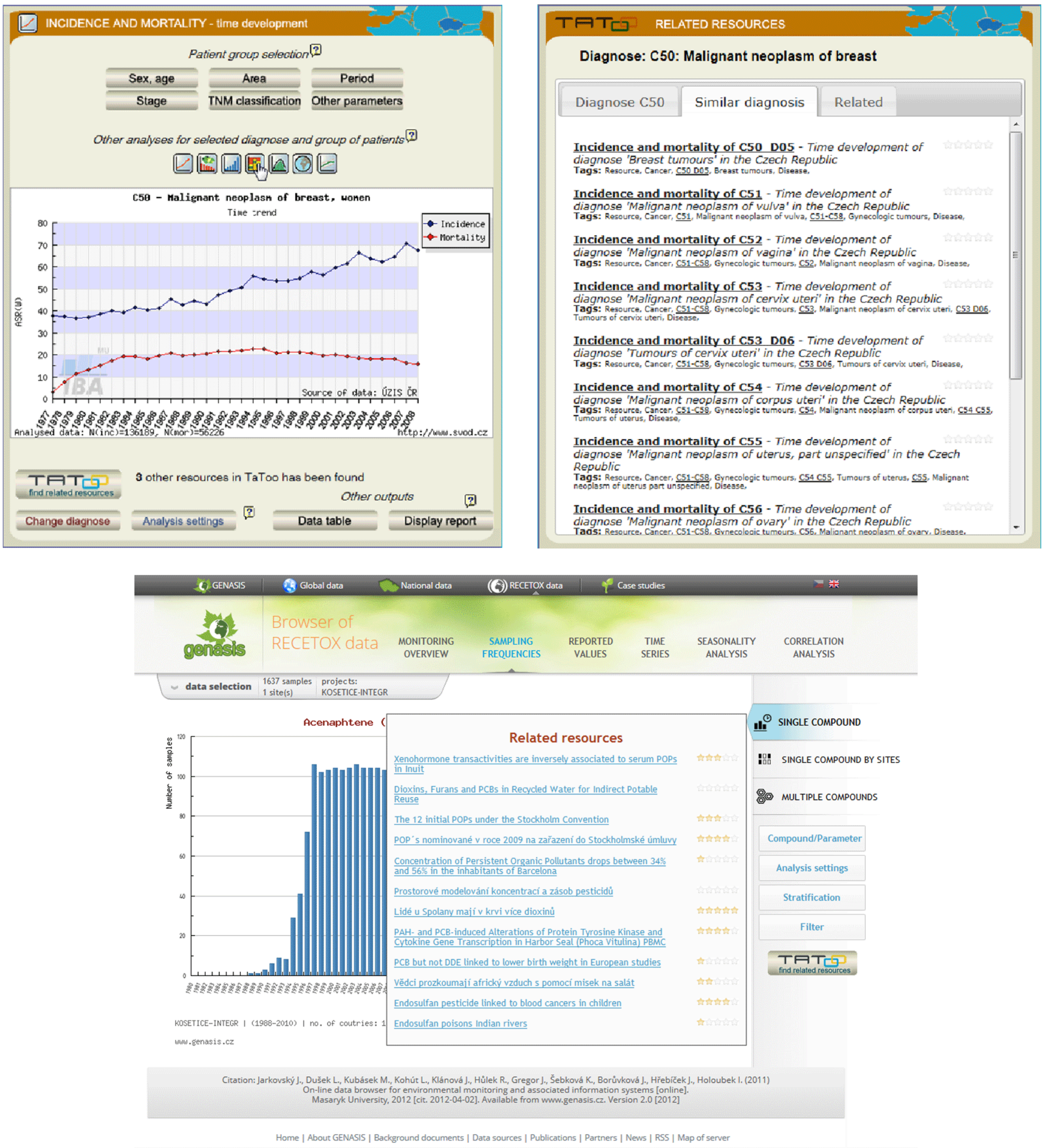

Figure 2
Integration of TaToo functionality into SVOD and GENASIS analysis tools

4.3 Generic discovery

The user wants to discover resources of a particular domain of interest matching certain criteria and keywords. The goal of this use case is to deliver improvements regarding result relevance compared to conventional search engine results. The user wants to find from the multitude of available resources the most interesting for his particular case, which is represented by the input information. The found result should therefore have a higher probability to fit the desired domain context.

Additional to domain specific information the system should also include other dimensions in the discovery like time range and geospatial information of the results, in order to further specify the domain of interest. The resulting list of resources should include additional information to the resource such as relevance to the search query, uncertainty information about the quality of the resource contains, file type of the resource etc. The search should not only deliver results in the original language used to specify the search query, it should also deliver results in foreign languages which match the domain context (e.g. user type search query in Czech language and TaToo Tools will be able to understand and give to the user also English resources fulfilling typed query). The first version of this implemented tool contains only a part of desired functionality, so only simple queries can be processed.

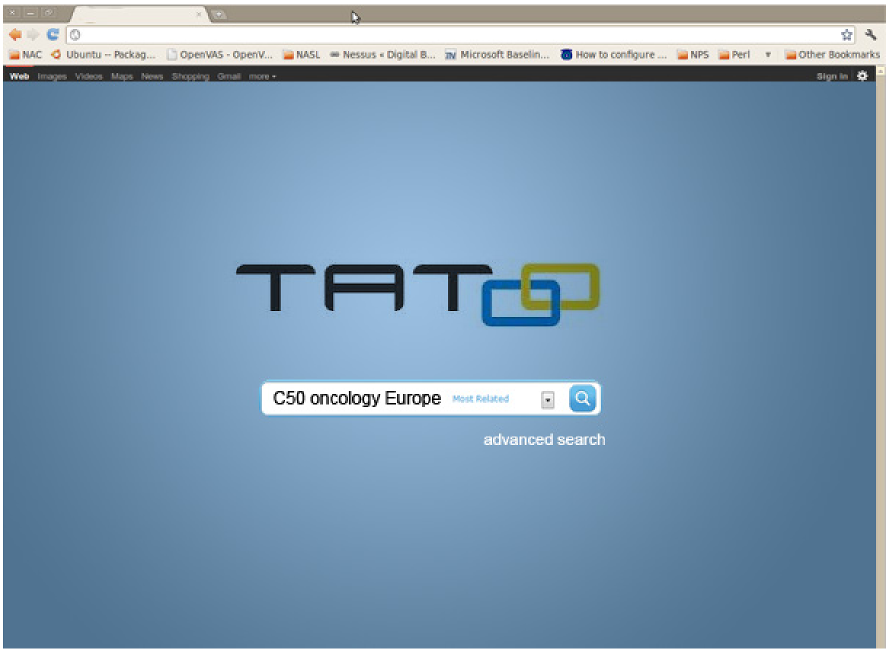

Figure 3
Interface for TaToo generic discovery

5. Conclusion

We have introduced GENASIS functionalities as a case study of human health and environmental risks evaluation together with its analytical tools. They are connected with TaToo tools and significantly enhance comprehensive discovery, tagging and understanding of information resources about the fate of POPs in the environment, their impacts on human health and enabling environmental risks evaluation.

We have also introduced the aims and the vision of the MU Scenario of the FP7 project TaToo for the provision of an appealing user interface for the semantic annotation of environmental resources, more specifically environmental data, information, web services and models. The paper also contains a short overview of domain ontologies for POPs contamination and cancer epidemiology domains. We have presented the TaToo framework and described how the GENASIS in MU Scenario is mapped onto the TaToo Framework Architecture, and have described in more detail several cases of selected validation use.

Acknowledgment

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement nr. 247893.

Bibliography

Dušek, L. (et al) (2005): The national web portal for cancer epidemiology in the Czech Republic. Proceedings of Enviroinfo 2005. 19th International Conference Informatics for Environmental Protection.. Masaryk University Press, Brno, pp. 434-439

Hřebíček, J. (et al) (2010): Anthropogenic Impact and Global Climate Change. Description of Validation Scenario in TaToo Project. In Hřebíček J., Pitner T., Ministr J.. 7. letní škola aplikované informatiky. Indikátory účinnosti EMS podle odvětví. Brno: nakladatelství Littera, pp. 6-23

Hřebíček, J. (et al) (2010a): Validation Scenario for Anthropogenic Impact and Global Climate Change for Tatoo. Proceedings of the Workshop "Environmental Information Systems and Services - Infrastructures and Platforms". CEUR-WS, Aachen.

Hřebíček, J. (et al) (2012): Ontology-Based Approach to the Discovery of Human Health and Environmental Risks Assessment, Proceedings of IEMSS 2012. International Congress on Environmental Modelling and Software Managing Resources of a Limited Planet, Sixth Biennial Meeting, Leipzig, Germany

Hřebíček, J., Pillmann, W. (2010): eEnvironment and the Single Information Space in Europe for the Environment. In EnviroInfo 2010. 24th International Conference on Informatics in Environmental Protection. Aachen: Shaker Verlag, pp. 45-55

Klánová, J. (et al) (2009): Towards the Global Monitoring of POPs - Contribution of the MONET Networks. RECETOX, Masaryk University, Brno

Kubásek, M. (et al) (2011): Semantics Annotations of Ontology for Scenario: Anthropogenic Impact and Climate Change Issues. In Jiří Hřebíček, Gerald Schimak, Ralf Denzer. In Environmental Software Systems. Frameworks of eEnvironment. 9th IFIP WG 5.11 International Symposium. ISESS 2011. Heidelberg:, Springer, pp. 398-406

Pariente, T. (et al) (2011): A Model for Semantic Annotation of Environmental Resources: The TaToo Semantic Framework. In Jiří Hřebíček, Gerald Schimak, Ralf Denzer. Environmental Software Systems. Frameworks of eEnvironment. 9th IFIP WG 5.11 International Symposium. ISESS 2011. Heidelberg: Springer.

Pillmann, W., Hřebíček, J. (2009): Information Sources for a European Integrated Environmental Information Space. In: EnviroInfo 2009. Environmental Informatics and Industrial Environmental Protection: Concepts, Methods and Tools. 23. International Conference on Informatics for Environmental Protection. Shaker Verlag, Aachen, pp. 341-352

Rizzoli, A. (et al) (2010): TaToo: tagging environmental resources on the web by semantic annotations. In: iEMSS 2010. International Congress on Environmental Modelling and Software. Modelling for Environment's Sake. iEMSS, Ottawa, pp.1192-1199

Urbánek J. (et al) (2010): Monitoring and Assessment of Environmental Impact by Persistent Organic Pollutants. In: Diamantaras K, Duch W, Iliadis L, editors. Artificial Neural Networks -- ICANN 2010. Vol 6354, Springer, Heidelberg, . pp. 483-488,

A.6. Application of Sensor Web Technology for Analysing Correlations between Health and Environmental Data (Jirka, S./Brauner, J./Bröring, A./Kunz, S./Simonis, I./Watson, K.)

Jirka, S./Brauner, J./Bröring, A./Kunz, S./Simonis, I./Watson, K. (2012): Application of Sensor Web Technology for Analysing Correlations between Health and Environmental Data. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 103-110.

Application of Sensor Web Technology for Analysing Correlations between Health and Environmental Data

Simon Jirka[1], Johannes Brauner[2], Arne Bröring[3], Siegbert Kunz[4], Ingo Simonis[5], Kym Watson[6]

Abstract

This paper introduces the European FP7 project EO2HEAVEN which aims at investigating the complex relationships between environment and health. To support such research a Spatial Information Infrastructure (SII) is introduced which allows combining different environmental data sources with health data sets and analysing correlations between these data sets. The paper presents the general challenges of combining environmental and health data, the EO2HEAVEN SII and its underlying improved Sensor Web concepts.

1. Introduction

Often, environmental conditions have an influence on human health. For example, air quality may have an impact on respiratory diseases or weather conditions may increase the spread of certain infectious diseases. Research is necessary to discover and understand these impacts and to provide people with guidance on how to minimize the health impact of environmental factors. For The European project EO2HEAVEN (Earth Observation and Environmental Modelling for the Mitigation of Health Risks, FP7 GA 244100) was started to provide experts from the health and environment domain with the necessary tools and data for their work (i.e. health and environmental data and services).

Several challenges need to be tackled to achieve the goal of better supporting health experts. These comprise on the one hand policy and security concerns which have to be considered when dealing with highly sensitive information such as health data sets. On the other hand, the integration of relevant data sources into analysis and processing tools of experts is still a cumbersome task (i.e. there are different data models, data types, and data formats that need to be integrated). To overcome these limitations, this paper introduces the EO2HEAVEN Spatial Information Infrastructure (SII) as an approach based on a service oriented, interoperable and distributed architecture.

In the next section the case studies underlying the EO2HEAVEN project are introduced. These case studies, covering cardiovascular and respiratory diseases as well as cholera, are a core driving factor of the EO2HEAVEN project. They deliver the requirements of domain researchers as input to the architecture and technology development of EO2HEAVEN. Further requirements result from the specific challenges that arise when integrating environmental and health data. These challenges are discussed in section 3. Subsequently, in section 4, the EO2HEAVEN SII is introduced which is the architectural foundation for

[1] 52°North GmbH, Martin-Luther-King-Weg 24, 48155 Münster, Germany, email: jirka@52north.org
[2] Technische Universität Dresden, Helmholtzstr. 10, 01069 Dresden, Germany, email: johannes.brauner@tu-dresden.de
[3] 52°North GmbH, Martin-Luther-King-Weg 24, 48155 Münster, Germany, email: broering@52north.org
[4] Fraunhofer IOSB, Fraunhoferstr. 1, 76131 Karlsruhe, Germany, email: siegbert.kunz@iosb.fraunhofer.de
[5] OGC Europe, United Kingdom, email: isimonis@opengeospatial.org
[6] Fraunhofer IOSB, Fraunhoferstr. 1, 76131 Karlsruhe, Germany, email: kym.watson@iosb.fraunhofer.de

fulfilling the needs of domain researchers. Central features of the SII are improved concepts for the OGC Sensor Web Enablement architecture as explained in section 5. Finally, the paper closes within an outlook on future work (section 6) and conclusions (section 7).

2. The EO2HEAVEN Case Studies

The research carried out in EO2HEAVEN is organized around three distinct case studies (CS) each dealing with particular problems located in Europe and southern Africa. By aligning the research work to case studies, the EO2HEAVEN methodologies and infrastructure are validated from a user perspective.

Case Study 1 – Environmental Effects on Respiratory and Cardiovascular Diseases in Dresden and Saxony, Germany

Various health and environment studies show regional proof that air pollution endangers human health, especially the respiratory and cardiovascular system (e.g. Strickland et al., 2010, McConnell et al., 2010). This link has so far only been poorly established for Germany's federal state Saxony. Thus, Saxony was chosen to be a case study region for EO2HEAVEN; in addition, it represents a typical central European region and could thus be of general interest. Combining human health data (from a public health insurer and official morbidity and mortality statistics or emergency hospital admissions) with air pollution and meteorological data (both measured by the regional governmental in-situ sensor network) is essential to derive health risks from exposure to air pollutants. Various geostatistical and health statistical models including visualization concepts have been developed to detect and analyse the correlation between the two data groups. The implementation is based on Web services deployed in a Spatial Information Infrastructure (SII) in the context of the regional INSPIRE (Infrastructure for Spatial Information in Europe) implementation.

Case Study 2 – Environmental Challenges to Health in the South Durban Industrial Basin, South Africa

The CS in Durban deals with air pollution and its influence on human health, as well. In contrast to the European study in Saxony, Durban (especially the South Durban basin) is exposed to major industrial air pollution. The percentage of childhood asthma is considerably higher than in any other report found worldwide. Over 50 per cent of school children living and learning in the direct neighbourhood of industrial emission sources suffer from acute or chronic asthma (Robins et al, 2002). Additionally, the reduced data availability (as compared to Saxony) in terms of health statistics and the lack of area-wide in-situ sensor observations pose challenges, although, in general, the same models and analyses as in CS1 are carried out in Durban. The usage of remote sensing imagery to support the health-environment analysis is currently being explored. EO2HEAVEN is developing methodologies and software aiming to support the work of local healthcare authorities and non-governmental organisations to warn citizens of risky environmental conditions. Additionally, an alert system based on mobile technology is being developed presenting an easy to understand user interface.

Case Study 3 – Cholera in Kasese, Uganda

CS3 investigates the dynamics of cholera outbreaks and the responsible pathogen Vibrio cholera (toxigenic) in the Kasese district in Uganda. It relates the outbreaks to potentially influencing environmental conditions and factors. To facilitate the design of re-active and pro-active counter measures and intervention strategies, the findings are of interest to researchers, decision makers in governmental organisations and non-governmental organisations active in cholera prevention and cholera outbreak emergency situations. EO2HEAVEN provides decision makers with spatiotemporal enabled visualizations of cholera outbreaks. Embedding the environmental findings into a social context is especially important to analyse the potential vulnerability of an area where the pathogen is found or known to exist. It is crucial to better understand when environmental conditions become favourable for an outbreak or intensify an outbreak once it has begun. The software tools and components currently being developed in EO2HEAVEN for CS3 integrate data sets from remote sensing and in-situ sensors and include data sets from microbiological field sampling campaigns and laboratory results. Scientists from different field should find, access, extract, visualize, analyse and model the provided data and publish their own findings in an easy manner.

3. Challenges when Integrating Health and Environmental Data

"In recent years a number of emerging and re-emerging diseases have been seen around the world […]. This is largely due to a continued neglect of basic public health practices in general and environmental health services in particular. Neglecting [..] [those services] often resulted in an increase in diseases associated with environmental factors." (South African National Department of Health, 2011). In a number of developing countries, this process was accompanied by a politically motivated change from a preventive to a curative health system, which further ignored research on correlations between environmental factors and epidemiological effects. In other countries, the development of policies for preventive health systems has not accelerated to full speed till date. Although some voices call for a salutogenic model as a theory to guide health promotion (e.g. Antonovsky, 1996), economists usually identify the preventive health care system as the most cost-efficient solution (e.g. Secker-Walker 1997, Kelly 2000, Coco 2005). The base requirement for any preventive system is the identification of the causes and the proper understanding of their correlation with (potential) effects. In turn, this understanding requires the systematic exploitation of environmental and public health data. With its beginnings in the development of social statistics in the 1800's when governments and individuals started to collect social data and information in a systematic way and the first use of 'social' data and information for epidemiological purposes, there are roughly 200 years of research and experience that could be used today (Simonis 2011). The poor understanding of the correlations between environmental factors and diseases is still an important impedimental factor in epidemiology.

Research in the domain of environmental health is often driven by a rather narrow focus. If it is the hydrocarbon-induced stress in earthworms or the evaluation of surface water quality in aquatic bodies under the influence of uranium mining, research is often not tackling the full line of correlations from base environmental factors to disease outbreaks and distribution patterns among humans. The reasons for those limitations are manifold, but often include the heavily restricted access to health data. It is easier to stop the research at the level of identification of potential adverse effectors rather than to proof and quantify the possible effect on humans in a complex environment of stress factors, environmental parameters, and individual susceptibility.

The privacy of medical information has always been a tenet of responsible medical care, but the electronic distribution and analysis techniques combined with developments of new medical tests and examination techniques have resulted in a new quality of health data and interrelated risk of illegal use. This data contains highly sensitive information and could, if misused, negatively influence the future of individuals, e.g. if the results of HIV or genetic susceptibility tests become public. In many cases, data privacy is now reflected in legal frameworks to prevent unscrupulous and self-interested exploitation of health data. Unfortunately, those legal frameworks make life harder for the research community as well. To ensure that data of an individual person cannot be recovered from an anonymised data set, high-resolution input data is aggregated multiple times to the level of obfuscation of individuals. This deliberate aggregation is in the opposite direction of general research practice, where the highest quality of results is strived for. In addition, the option to trace back from aggregated datasets to individuals often includes additional potential for health care and health research. There is no pure technological solution for this situation. In a world that continuously commercializes research, no isolated technology can help. In contrast, it requires a highly interwoven framework of ethical, technical, and legal rules and regulations to address the issue of data privacy. Those frameworks have to be rolled out on an international level to allow cross-border analysis and comparability.

The next section introduces the EO2HEAVEN Spatial Information Infrastructure which is the technological basis for achieving the integration of environmental and health data.

4. The EO2HEAVEN Spatial Information Infrastructure

The specification of the implementation architecture of the EO2HEAVEN Spatial Information Infrastructure (SII) is the basis for all EO2HEAVEN developments. Particular emphasis is put on the support of environmental and health monitoring as required by the three EO2HEAVEN case studies.

The architectural work in EO2HEAVEN is carried out iteratively in order to proceed step-by-step in the architectural specifications. To ensure a coherent methodological approach across all development cycles, each cycle results in one version of the SII Implementation Architecture. Currently work on the 3rd iteration is on-going. The EO2HEAVEN architecture incorporates further developments of advanced concepts for Sensor Web Enablement (SWE), distributed Geo-Processing and Spatial Decision Support. This includes event-based interactions across all functional domains and the inclusion of models from the environmental and health domains as virtual sensors. The EO2HEAVEN architecture specification is structured as a six part (Part I to Part VI) document with a coherent and redundancy-free set of architectural specifications including concept developments.

The structure of the SII architecture is also oriented at an interpretation of the five viewpoints of the ISO Reference Model for Open Distributed Processing (RM-ODP). These viewpoints (partly combined) are specified in the six document parts of the SII architectural specification. It continues the series of architecture specifications of previous European FP6 projects which resulted in OGC documents as follows: The foundation was set by the ORCHESTRA project (http://www.eu-orchestra.org) and its Reference Model for the ORCHESTRA Architecture (RM-OA), approved as an OGC best-practices document (OGC 07-097). The RM-OA was extended by the SANY project (http://sany-ip.eu) in its Sensor Service Architecture (SensorSA), accessible as an OGC discussion paper (OGC 09-132r1).

Referring to the original copyrights of these documents and in agreement with their editors, the EO2HEAVEN project inherits and extends them in form of the present SII implementation architecture specification.

The published EO2HEAVEN SII architecture of the 2nd iteration focuses both on the sensor architecture and on the EO and health data aspects. It investigates the consequences of special health data privacy and security requirements on the architecture. Relevant security aspects include security setting descriptions, mechanisms to establish security and how to propagate security settings through processing chains. The SII provides further extensions and refinements, e.g. taking into account the requirements to share and process huge amounts of data sets provided by earth observation agencies and health institutions in order to investigate and assess correlated risks.

Further major topics of the EO2HEAVEN SII are processing and fusion services, processing of quality information, handling sensor data uncertainty, its encoding and visualization, etc. The uncertainty of sensor measurements (e.g. the relative or absolute accuracy of the manufacturer's device) is encoded in OGC Sensor Model Language (SensorML) documents for each sensor. An interpolation process can take account of the data accuracy by acquiring it automatically from the SensorML descriptions accessible via an OGC Sensor Observation Service. The result of such an interpolation process is a coverage, i.e. a set of estimated property values for the sampling points together with a quantified description of their uncertainty. Figure 1 illustrates as an example the special situation of a two dimensional wind values interpolation in a selected area as a coverage layer (heat map) of the resulting wind speed in combination with an arrow field indicating the wind direction (white arrows). It is processed using the measured mean wind values (red arrows) at three measurement stations (red dots) via an OGC based fusion SPS/SOS Web service. This includes also the adequate visualization of the uncertainty in diverse illustrations such as a heat map using in parallel both a colour scale (in areas with results of a low uncertainty) encodings and grey scale encodings (in areas with uncertain results above a given threshold due to the long distance from the measurement stations).

Other challenges are advanced services e.g. to adjust the different data resolutions, to handle intermittent data (e.g. due to sensor unavailability or communication interruptions) or to identify and handle data outliers (e.g. due to sensor failures). However, this architectural specification still reflects a work in progress so that further enhancements are expected by the end of the project.

All versions of the EO2HEAVEN SII architecture will be publically available, whereas at least the last one shall be disseminated by means of the OGC channels. The next section focuses on a specific part of the SII architecture, the OGC Sensor Web Enablement (SWE) framework and the advanced SWE concepts that were developed within EO2HEAVEN.

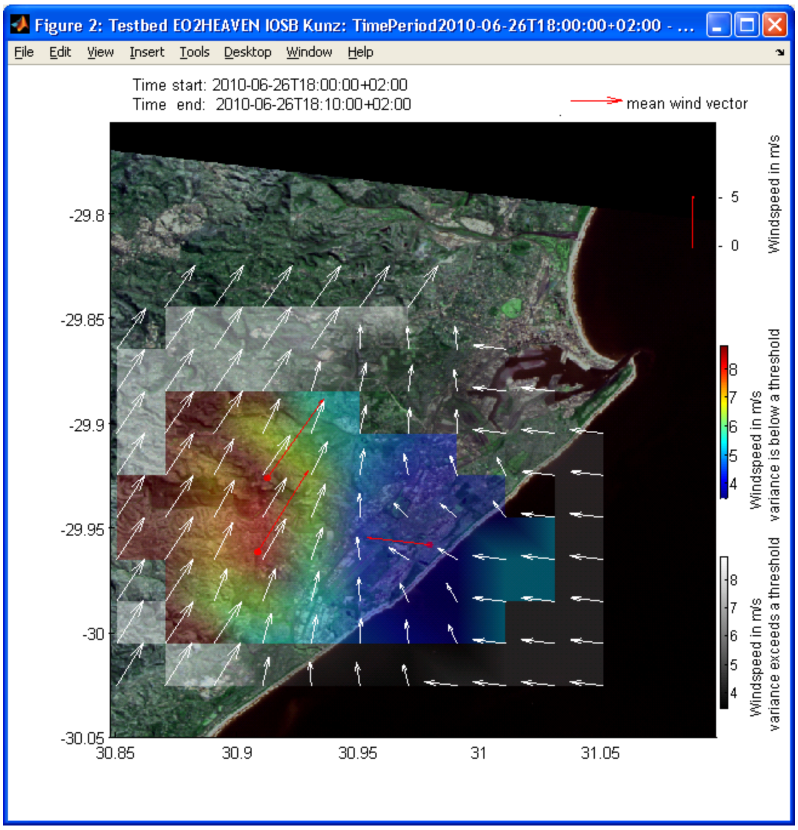

Figure 1
Visualisation of the Uncertainty of Interpolated Wind Values by Combining Colour and Grey scale Encodings Depending on the Local Variance Values of the Interpolation (Durban in South Africa)

5. Advanced Sensor Web Concepts

When investigating relationships between environmental influences and health, sensor data plays a central role. This comprises on the one hand historical observation data to analyse changes that occurred during the course of time and on the other hand real-time data for building alerting mechanisms in case of critical situations. The Sensor Web Enablement (SWE) technology of the Open Geospatial Consortium (OGC) is used within EO2HEAVEN to integrate heterogeneous sensor data sets with health data. To make SWE fit for the requirements of the EO2HEAVEN Case Studies several challenges had to be addressed. This section introduces these challenges and describes how they were tackled.

An important feature of the OGC SWE standards is their domain independent character so that a very broad range of usage scenarios and applications can be covered. This leads at the same time to a need for flexibility in the different SWE specifications which might hinder interoperability (e.g. the same functionality can sometimes be achieved through different ways). Profiles of the SWE standards, that take into account the specific needs of certain domains, are a good approach to improve interoperability within EO2HEAVEN and to reduce the necessary implementation effort. As a first step in this direction, a lightweight Sensor Observation Service profile for stationary in-situ sensors was developed. This profile can be seen as a least common denominator of domain specific profiles that ensures a common approach between these profiles. For example, this profile offers clear guidance on the minimum set of metadata to be provided to describe sensor data sets, and on which filtering mechanisms need to be supported when querying for sensor data.

Besides accessing sensor data through the EO2HEAVEN infrastructure, it is equally relevant to provide researchers an easy way to integrate and publish their observation data in the EO2HEAVEN Sensor Web architecture. In the past, the publication process required a general understanding of the SWE architecture and its different standards. However, such IT specific knowledge cannot be expected from a domain expert who is primarily interested in working with observation data. Thus the structure of the underlying databases as well as the Web service requests necessary for publishing observation data needs to be hidden from the user. To achieve this goal, EO2HEAVEN has developed an import tool for publishing sensor data on the Sensor Web. This tool provides the user with a graphical user interface to describe the structure and content of existing sensor data files (i.e. CSV files). Through this process the user is able to define how information such as the measured value, the time stamp of measurements, etc. is encoded in a data file. Using this information, the import tool is able to automatically convert the observation data to the corresponding SWE data models and encodings (i.e. according to the Observations and Measurements standard) and to insert the data into Sensor Web components.

After the sensor and health data sets have been published on the EO2HEAVEN SII, the next step is to make use of the data. Thus, it is necessary to link the sensor data sets provided through OGC SWE services to interoperable processing services which perform the processing required by the domain researcher’s analyses. For this purpose the OGC Web Processing Service and Sensor Planning Service specifications have been chosen. Using the OGC Web Processing Service, researchers receive the opportunity to link any kind of input data provided by Sensor Web services to their processing and analysis models. By relying on interoperable standards, one can ensure a high degree of freedom in selecting data sets and accompanying processing algorithms: data sources and processing components can be flexibly exchanged as long as they adhere to the SWE and Web Processing standards of the EO2HEAVEN SII.

Further challenges addressed by EO2HEAVEN to improve the applicability of the SWE framework comprise the uncertainty of sensor data, the integration of remote sensing data (i.e. raster data sets such as satellite images) with in-situ data (e.g. local air quality measurements), and the discovery of sensors, sensor data, and Sensor Web services.

To sum it up, EO2HEAVEN relies with its SII on advanced Sensor Web concepts that are driven by the needs of the environment and health domains. Special focus has been put on increased interoperability and user friendliness, especially for non-IT domain experts. Thus, the Sensor Web technology is a core element for realising the Case Studies introduced in section 3. The resulting Sensor Web software components are published as open source software, e.g. on the 52°North platform (http://52north.org).

6. Outlook and Future Work

The Sensor Web concepts used in EO2HEAVEN are mainly intended for a pull based access to sensor data. For example, if a researcher wants to perform an analysis using sensor data, he is able to request this data from a Sensor Observation Service (SOS) and subsequently receives the matching observation document. However, such a pull-based mechanism is not always sufficient. For example, an alerting application needs to receive new sensor measurements as soon as they are available in order to quickly dispatch any alerts. Thus, in the future further work should be done to extend the currently available publish/subscribe mechanisms of the SWE architecture. Especially the currently on-going activities of the OGC Publish/Subscribe Standards Working Group are likely to be an important input for future versions of the SII.

On the one hand, the case studies in Saxony and Durban either lack a fine-granular or an area-wide air pollution sensor network necessary to monitor the current local conditions properly. On the other hand, enlarging the number of regular sensors would be too expensive. To tackle both issues, extending the official sensor net by a larger number of cheaper sensors (e.g. http://www.kickstarter.com/projects/edborden/air-quality-egg) could be promising. Even if they provide less precise measurements, they are suitable to show a rise or fall of certain parameters. Additionally, a larger number of sensors is expected to even out measurement errors (assuming there are no systematic errors of a device class) and raise the quality of the sensor network as a whole.

An important aim of EO2HEAVEN is to establish persistent data accessibility of the various environmental data sources to the environmental science community via OGC SWE services beyond the project end. The EO2HEAVEN components developed for the Case Studies will be implemented in a long term and stable way, so that local staff is able to maintain their functionality in the future. The results of the EO2HEAVEN project will be published in a set of public deliverables and in a separate EO2HEAVEN book on best practices, which continues the book series started in the previous projects ORCHESTRA and SANY.

7. Conclusion

This paper has introduced the EO2HEAVEN project which provides a framework and tools for analysing the complex correlations and interdependencies between environmental factors and human health. Special challenges when combining environmental and health data were discussed: due to the highly sensitive character of health data special focus needs to be put on privacy and data protection issues. Furthermore, a common framework is needed that facilitates the integration of heterogeneous health and environment data sources into analysis and processing tools of domain experts.

Based on the three EO2HEAVEN Case Studies, the EO2HEAVEN Spatial Information Infrastructure (SII) was designed to support experts in their research. This ensures that the project results are in line with the requirements of practitioners.

Sensors are of special importance to determine the state of the environment (real-time as well as historic information). Consequently, the OGC Sensor Web Enablement (SWE) framework is a core element of the EO2HEAVEN SII. To support the needs of researchers, several advances to the SWE framework have been developed such as profiles for increased interoperability, user friendly data publication tools, concepts for handling uncertainty, and best practices for combining in-situ as remote sensing data.

In summary, the EO2HEAVEN project builds on results of previous European projects and advances these concepts to better support the integrated analysis of environmental and health data sets. Thus, researchers receive a valuable set of tools that support their work of understanding the influence of the environment on human health.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244100.

Bibliography

Antonowsky, A. (1996): The Salutogenic Model as a Theory to Guide Health Promotion, in: Health Promotion International, 11, pp. 11-18

Brauner, J. (et al.) (Ed.) (2011): Specification of Advanced Geo-Processing Services (second issue), Public deliverable D4.9, available online: http://www.eo2heaven.org/sites/default/files/D4.9_Specification_of_Advanced_Geo-processing_Services_Issue_2.pdf

Coco, A. (2005): The Cost-Effectiveness of Expanded Testing for Primary HIV Infection, in: Annals of Family Medicine, 3 (5), pp. 391-399

Jirka, S. (et al.) (Ed.) (2011): Specification of the Advanced SWE Concepts (second issue), Public deliverable D4.8 available online: http://www.eo2heaven.org/sites/default/files/D4.8_Specification_of_the_Advanced_SWE_Concepts_Issue_2.pdf

Kelly, C. S. (et al.) (2000): Outcomes Evaluation of a Comprehensive Intervention Program for Asthmatic Children Enrolled in Medicaid, in: Pediatrics 105, pp. 1029-1035

Kunz, S. (et al.) (Ed.) (2011): Specification of the SII Implementation Architecture (second issue) Parts I-VI; Public deliverable D4.7 available online: http://www.eo2heaven.org/sites/default/files/D4.7%20Specification%20of%20the%20SII%20Implementation%20Architecture.pdf

McConnell, R. (et al.) (2010): Childhood Incident Asthma and Traffic-related Air Pollution at Home and School, in: Environ Health Perspect., 2010 Mar 22 (Epub ahead of print)

Robins T. (et al.) (2002): Air Contaminant Exposures, Acute Symptoms and Disease Aggravation among Students and Teachers at the Settlers' School in South Durban. Interim Report, University of Natal Faculty of Health Sciences/University of Michigan School of Public Health, February 2002

Secker-Walker R. H. (et al.) (1997): A Mass Media Programme to Prevent Smoking among Adolescents: Costs and Cost-Effectiveness, in: Tobacco Control 6, pp. 207-212.

Simonis, I., van der Merwe, M. (2011): Earth Observation and Environmental Modelling for the Mitigation of Health Risks such as Cholera, Cardio-Vascular and Respiratory Diseases, in: Proceedings of IST Africa 2011.

South African National Department of Health (2011): National Environmental Health Policy. National Department of Health

Strickland, M. J. (et al.) (2010): Short-term Association between Ambient Air Pollutants and Pediatric Asthma Emergency Department Visits, in: Am J Respir Crit Care Med, Apr 8 (Epub ahead of print)

Usländer, T. (et al.) (Ed.) (2007): Reference Model for the ORCHESTRA Architecture Version 2. OGC Best Practices Document 07-097, 2007, available online: http://portal.opengeospatial.org/files/?artifact_id=23286

Usländer, T. (et al.) (Ed.) (2009): Specification of the Sensor Service Architecture Version 3.0 (Rev. 3.1). OGC Discussion Paper 09-132r1, 2009, available online: http://portal.opengeospatial.org/files/?artifact_id=35888&version=1

A.7. ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb (Davila, S./Bešlić, I./Pečar-Ilić , J./Šega, K.)

Davila, S./Bešlić, I./Pečar-Ilić , J./Šega, K. (2012): ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 111-118.

ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb

Silvije Davila[1], Ivan Bešlić[1], Jadranka Pečar-Ilić[2] and Krešimir Šega[1]

Abstract

The most significant research and development activities concerning air quality assessment that is carried out by the Institute for Medical Research and Occupational Health (IMORH) according to the "Program to protect and improve air quality in the City of Zagreb" is shown. For the first time, information on air quality in the City of Zagreb is experimentally presented showing air quality indexes, easily understandable to the citizens. The model that we used to display the air quality index is CAQI model, which is the most common in the European Union and facilitates the international comparison of near real time air quality. In this paper, a proposal for near real-time presentation of air quality information for the City of Zagreb, using sensor data and Web GIS technology is elaborated. Presently, data are available only from four automated monitoring stations, but activities are carried out towards automated stations within local city network.

1. Introduction

1.1 Croatian air quality legislative framework

Air Protection Act (Official Gazette No. 130/11) sets up the objectives to protection and improvement air quality in the Republic of Croatia according to the requirements of CAFE directive. Air quality monitoring was started and preformed only on local level 50 years ago. Ministry of Environmental and Nature Protection is responsible today for air quality assessment in the entire state territory. Accordingly, Croatian government has established national air quality monitoring network 10 years ago. Air quality monitoring on national and local level has been adjusting according to the CAFE directive during last 7 years (Official Gazette, No. 61/08). New preliminary air quality assessment will be carried out in a period of next five years, especially at rural background monitoring stations. Revision of existing zones and agglomerations will be performed based on the results on this new assessment. Presently, air quality monitoring covers the measurement of the following pollutants: SO_2, NOx, PM10, PM2.5, O_3, CO, NH_3, H_2S, BTX, determination of heavy metals and PAH in PM10, as well as the meteorological parameters. Source apportionment (local and long range Tran's boundary pollution) is carried out based on the measured data results.

The Meteorological and Hydrological Service is responsible for air quality monitoring within the national network. Energy Research and Environmental Protection Institute (EKONERG) performs maintenance, calibration services and validation of the results. Croatian State National network consist of 11 automatic air quality monitoring stations in settlements and industrial zones and 12 new rural background monitoring stations.

Local air quality monitoring networks with the long tradition of the basic pollutant monitoring are organized across the country's territory. The representative bodies of local and regional governments are responsible for carrying out the assessment of air pollution levels in local networks. Air quality data are de-

[1] Institute for Medical Research and Occupational Health, Environmental Hygiene Unit, Ksaverska road 2, 10 001 Zagreb, Croatia. Email: sdavila@imi.hr

[2] Ruđer Bošković Institute, Division for Marine and Environmental Research, Bijenička road 54, 10 000 Zagreb, Croatia.

livered to Croatian Environment Agency (CEA) responsible for timely data collecting into Air Quality Information System (AQIS). AQIS makes an integral part of National Environmental Information System (Butuči/Mesić 2009), which has been developed and maintained in line with EU INSPIRE directive and SEIS principles (Hrebicek/Pillmann 2009).

1.2 Air quality monitoring in the City of Zagreb

Air quality monitoring in the City of Zagreb is performed at monitoring stations from two monitoring networks in order to cover the whole city area. Three automatic stations within national network are classified as traffic stations (Fig. 1).

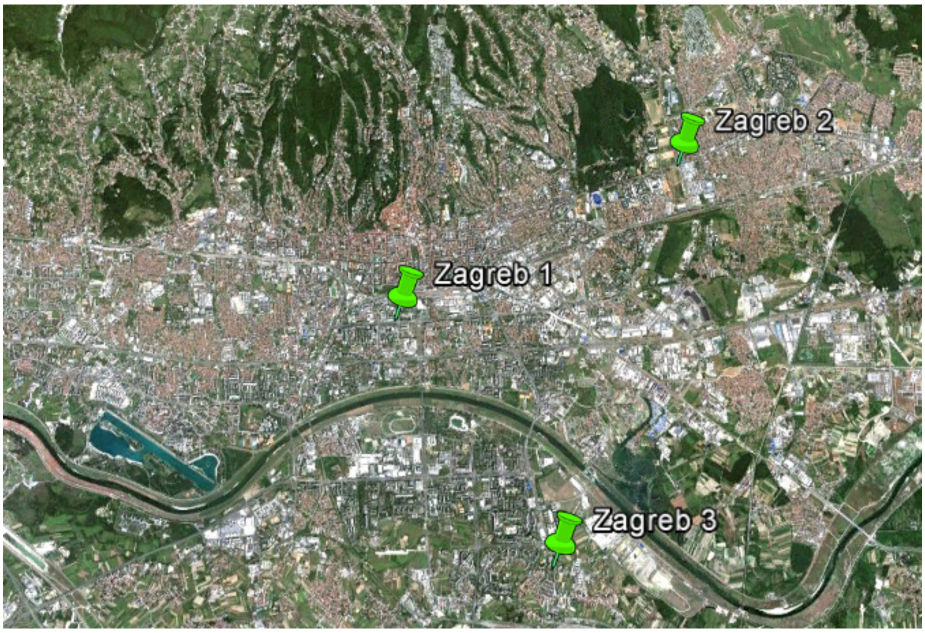

Figure 1
Automatic air quality monitoring stations within national network located in Zagreb City

Six monitoring stations within local network are classified as traffic, industrial or urban background stations (Fig. 2). The only automatic monitoring station within the local network is located at the Institute for Medical Research and Occupational Health (IMROH) and classified as urban background station. IMROH is responsible for the local network of the City of Zagreb following the scientific experience and development in air pollution field and maintaining the continuity of monitoring according to the "Program to protect and improve air quality in the City of Zagreb" (Mikulić et al. 2008). One of the most important objectives is to enable the citizen's right to be accurately informed on status of the ambient air quality at the location they live and work, in understandable way for everybody. IMORH has been accredited through EN 15025 for mass concentration determination of PM10 and PM2.5 particle fractions (EN 12341:1998 and EN 14907:2005), as well as for the determination of the following gases: ozone, nitrous oxide, sulphur dioxide and carbon monoxide (EN 14625:2005, EN 14211:2005, EN 14212:2005 and EN 14626:2005, respectively).

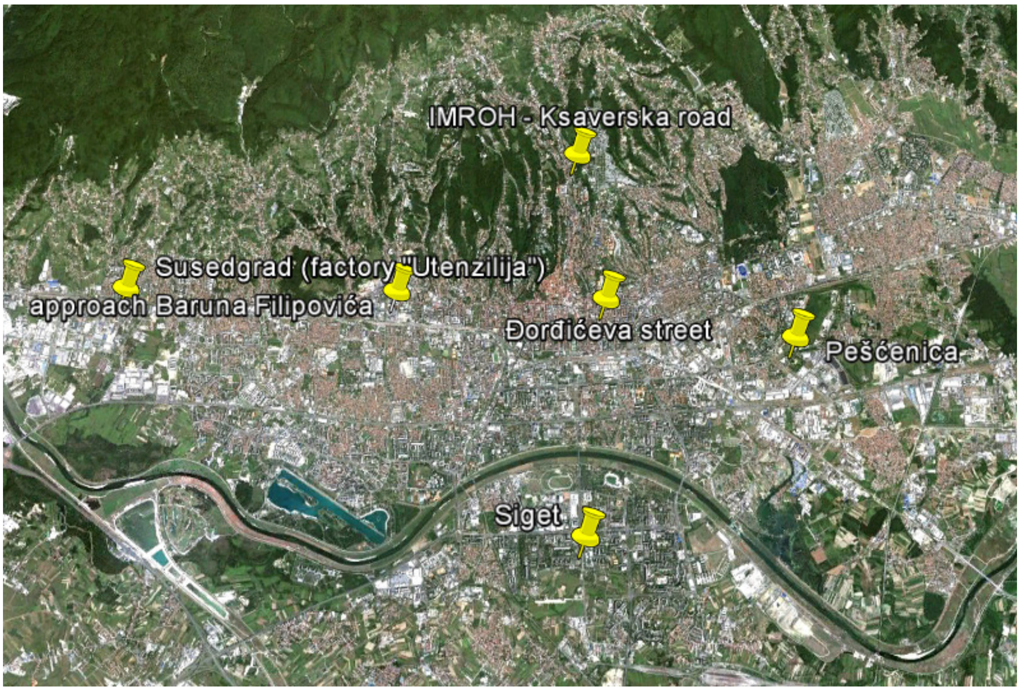

Figure 2
Air quality monitoring stations within local network of the Zagreb City

Since 2010, the specialized information system for presentation of air pollution information has been developing at the IMROH according to the EU and national air quality and information exchange legislation. At this point, two important functionalities are enabled in order to fulfill IMROH roles at the both national and local level (Davila/Bešlić/Pečar-Ilić/Šega 2011). The application IMI DEM Maker is developed independently to create Air Quality - DEM files, which entail setting up a file transfer to an information system for air quality of CEA. Web application for air quality monitoring from an automated station within local network (i.e. http://kvaliteta-zraka.imi.hr/index_eng.php) is a part of Institute's Web site available to different groups of users and citizens of Zagreb. The main goal is to develop more comprehensive geoportal and add the functionalities such as creation of an archive of pollutant concentrations for each monitored pollutant by days, introduce the air quality indicators and an air quality prediction model in combination with raster images of Zagreb.

Presently, the air quality information in the Republic of Croatia (as well as in the City of Zagreb) consists of raw monitoring data or corresponding categories of air quality for the past year, only, which is more suitable for air quality experts rather than general public.

In following paragraphs, we present a proposal based on the best practice guidelines and the methodology set up by the CITEAIR project (co-funded by first by INTERREG IIIC then INTERREG IVc). The main aspects of development process of the application system are explained, the main components of the system and information flows are presented. An example of interactive dynamic map with monitoring stations and corresponding hourly values of air quality indexes for the City of Zagreb is shown.

2. Air quality index

Air quality index had begun to develop 1960 in Toronto, Canada (Garcia/Colosio/Jamet 2002) for the purpose of informing the general population on air quality. In Europe air quality index first began to be used in France in 1995. Till year 2000, the 47 countries used air quality index. In order to determine the air quality index they used limit value prescribed by law, with combined of mathematical methods and restriction methods.

2.1 CAQI

CAQI model or Common Air Quality Index was created in the project CITEAIR (an INTEREG IIIc project, 2006). The index is designed for the purpose of comparing air quality in real time between European cities (van den Elshout et al. 2010, Hodges et al. 2005). In the early stages of the project they noted that many cities use other air quality indexes that are very difficult to compare. Because of that, they developed a new air quality index called CAQI.

CAQI has a scale from 1 to 100, where 1 is marked with the best air quality, while higher values are associated with concentrations mentioned in the European Air Quality Directive (Directive 2008/50/EC). Index is calculated using the grid shown in Table 1. For each pollutant the hour index is calculated. While the overall index for a given measuring site is defined by taking the worst of the calculated index.

Table 1
Pollutants and calculation grid for the CAQI
Source: van den Elshout and Leger, 2007

Index Class	**Grid**	**Traffic**				**City Background**					
		Mandatory			Auxiliary	Mandatory				Auxiliary	
		NO_2	PM_{10}		CO	NO_2	PM_{10}		O_3	CO	SO_2
			1 h	24 h			1 h	24 h			
Very Low	0	0	0	0	0	0	0	0	0	0	0
	25	50	25	12.5	5000	50	25	12.5	60	5000	50
Low	25	50	25	12.5	5001	50	25	12.5	60	5001	50
	50	100	50	25	7500	100	50	25	20	7500	100
Medium	50	100	50	25	7501	100	50	25	120	7501	100
	75	200	90	50	10000	200	90	50	180	10000	300
High	75	200	90	50	10001	200	90	50	180	10001	300
	100	400	180	100	20000	400	180	100	240	20000	500
Very high	>100	>400	>180	>100	>20000	>400	>180	>100	>240	>20000	>500

3. An Architecture of Web Application

Activity flow of the application system for display the air quality in the City of Zagreb is presented by Activity diagram of the Unified Modeling Language (UML) in Figure 3.

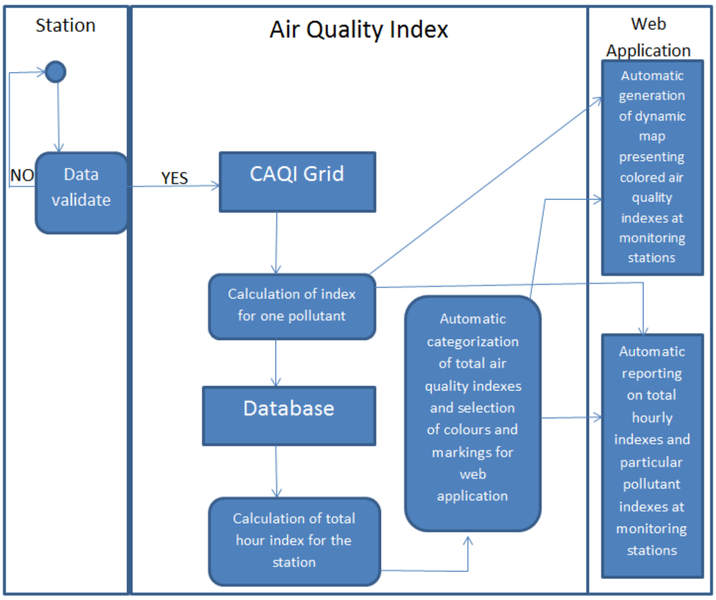

Figure 3
UML Activity Diagram of the System

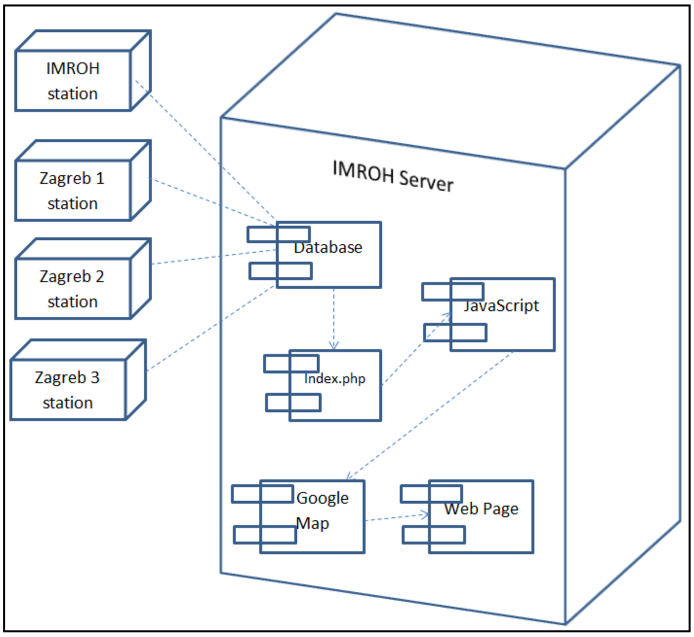

Figure 4
UML Component Diagram of the System

When downloading the data from monitoring stations, data is check whether it is validated or not. If data is not validated such data is not stored in the database. Data that passed the validation process is fed into the CAQI grid. With that grid air quality index for each pollutant from each monitoring station is automatically calculated using mathematic formula for calculating index. Air quality index for each pollutant is stored in a database, and then calculates the total hourly air quality index for each measuring site. After calculating a total air quality index, system automatically assigned a color and icon for a web application for each monitoring station. Web application automatically displays the report for hourly air quality index for a given monitoring station, and also automatically generates a dynamic map with markers of air quality index.

Organization and relationships of the components of application system for display the air quality in the City of Zagreb are shown by UML Component diagram in Figure 4. Data from local and national monitoring networks are collected in a database. The database contains the concentration of pollutants from all automatic station in Zagreb. Concentration data from the database are automatically converted to air quality index using php and JavaScript applications. When the air quality index for each pollutant is calculated, the overall air quality index for the measuring site is automatically assigned to the Air Quality Index Google map. These data are displayed on an experimental website which will be accessible by public in textual, numerical and in the form of a map.

4. Web application example

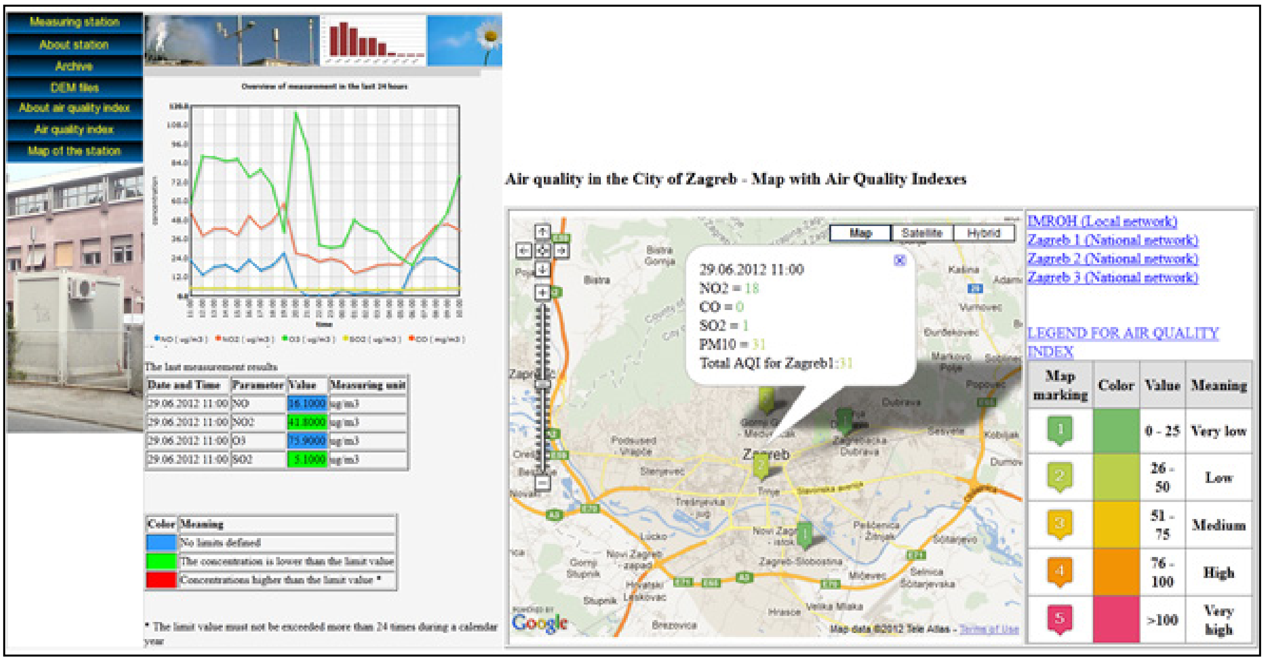

Figure 5

a) Web application of IMROH measuring station according Croatian Air Protection Act (left side)

b) Web application of Zagreb applying the CAQI methodology and in accordance with EU (right side)

Web application (Fig. 5a) for automatic monitoring station on IMROH (http://kvaliteta-zraka.imi.hr/index_eng.php) was done according the Croatian Air Protection Act. By the law we can only defined if the mass concentration of an hour pollutant is higher or lower than the legally permitted values.

Showing this data to the person who is not familiar with the Air Protection Act is completely incomprehensible. Therefore experimental Web application (Fig. 5b) of air quality in Zagreb (http://kvaliteta-zraka.imi.hr/aqi_experimental_eng.php) has been developed in accordance with European directives and applying CAQI methodology and proposed to the authorities of the Zagreb City. It shows interactive dynamic map of the City of Zagreb with the markings of automatic monitoring stations. The icons on the map are changed depending on the air quality index. By selecting individual monitoring station the details related to air quality index are showed. In this way, a person who is not familiar with the Air Protection Act can know how the air quality near the place where he is located is. Table 2 shows the hourly air quality index for each pollutant as well as total hourly air quality index for that location which is measured at national and local network stations (i.e. Zagreb 1, 2, 3 and IMROH, respectively) located in the Zagreb City.

Table 2
Total and components hour air quality indexes for automatic monitoring stations located in the Zagreb City (from 6th July 2012.)

Measuring site	Components	Concentration	Unit	AQI	Total AQI
Zagreb 1	NO_2	41	µg/m3	21	32
	CO	0	mg/m3	0	
	SO_2	0	µg/m3	0	
	PM10	32	µg/m3	32	
Zagreb 2	NO_2	27	µg/m3	14	20
	CO	0	mg/m3	0	
	SO_2	2	µg/m3	1	
	PM10	20	µg/m3	20	
Zagreb 3	NO_2	9	µg/m3	5	28
	CO	0	mg/m3	0	
	O_3	2	µg/m3	1	
	PM10	28	µg/m3	28	
IMROH	NO_2	48	µg/m3	24	39
	SO_2	5	mg/m3	3	
	O_3	92	µg/m3	39	

5. Conclusion

In this paper we present proposal for real-time presentation of air quality information for the City of Zagreb. The web application has been developed accordingly to the EU legislation and CAQI methodology.

Web application for monitor air quality for the City of Zagreb will be in the future a part of more comprehensive Web portal. We intend to develop new subsystems of IMROH's information system to completely fulfill recommendations set by EEA. For example, we will add the new functionalities such as an air quality prediction model in combination with raster images of the Zagreb City and trajectories.

Bibliography

Butuči, J., Mesić, H. (2009): Croatian Environment Information System Conceptual Model, Towards eEnvironment, Brno, pp. 153-158

Croatian Government (2008): Air Quality Protection and Improvement Plan of the Republic of Croatia for the period 2008-2011, Official Gazette, No. 61/08, Zagreb, pp. 141

Croatian Parliament (2011): Croatian Air Protection Act, Official Gazette No. 130/11, Zagreb (in Croatian)

Davila, S., Bešlić, I., Pečar-Ilić, J., Šega, K. (2011): An automated web-based system for air quality monitoring, 34 Int. Convention on ICT, Electronics and Microelectronics, IEEE Region 8, Opatija, Croatia, pp. 816-819

Garcia, J., Colosio, J., Jamet, P. (2002): Air Quality Indexes, EnviroInfo 2002, Wien, Austria

Hodges, N., van den Elshout, S., Heich. H.-J., Lad, C., Leger, K., Nussio, F. (2005): CITEAIR – Common Information to European Air, EnviroInfo 2005, Masaryk University Brno, pp. 518-522

Hrebicek, J. Pillmann, W. (2009): Shared Environmental Information System and Single Information Space in Europe for the Environment: Antipodes or Associates?, Towards eEnvironment, Brno, pp. 447-458

Mikulić, J. (et al.) (2008): Program to protect and improve air quality in the City of Zagreb, Zagreb, pp. 103, (in Croatian)

van den Elshout, S., Leger, K. (2007): A review of existing air quality indices and the proposal of a common alternative, Final version, in Component 3: Comparing Urban Air Quality Across Borders, CiteAir INTEREG III project, DCMR, Environmental Protection Agency Rijnmond, pp. 35

van den Elshout, S. (et al.) (2010): CAQI Air quality index, Citeair II 2010, Ljubljana, Slovenia

A.8. Interlink between Environment and Health Information (Pillmann, W.)

Pillmann, W. (2012): Interlink between Environment and Health Information. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./ Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 61-67.

Interlink between Environment and Health Information

Werner Pillmann[1]

Abstract

Environmental data and information are describing in particular the environmental situation, characterizing the basic conditions for the individual quality of life. Programmatic documents, e.g. from the European Ministerial Conferences on Environment and Health 1989-2010, leave no doubt about the strategic role of information management. This paper outlines some aspects on the interlink between environment and health information and research from an information processing point of view. A Meta-model is presented, which outlines the role of environmental informatics for the supply of environmental and health information. The Meta-Model has a close relationship to DPSIR and DPSEEA[2] structure and specifies more in detail the connection between environmental and health information.

1. Introduction

The topic environment and health is a fragmented area. It connects results from medical and environmental research with policy making and administrative acting on the basis of legislation. This interlink shows effective after the 70ies especially in USA, Japan and Western Europe on the basis of early observations during London smog, Minimata disease, DDT utilization etc. A survey can be found in the environmental world history of Radkau (2011) describing the "Ecological Revolution" from the19th century until the present days. Results primarily coming from environmental research forced the foundation of environmental ministries and agencies and epidemiological research results prove empirical evidence of environmental stress on man and biosphere.

Environment and Health is an all-embracing concept in the scientific community, expanding environmental research considerably. In reverse order Environment and Health can be seen as subarea of public health and is close related to epidemiology and occupational health. Its basis is high developed medical knowledge which integrates environmental conditions as an additional factor in its scientific repertoire. Finally Environmental health aims to investigate these interrelations, to understand the dynamics and to promote and protect health via environmental pathways (Fehr 2002).

For politicians Environment and Health is a commonly used placeholder for activities highlighting the effort in decisions to keep both human environment and health relevant effects under consideration. In the 2012 United Nations Conference on Sustainable Development (Rio+20) "The Future We Want" (http://www.uncsd2012.org/). Public Environment and Health (PHE) is formulated in journalistic style: Health at the heart of sustainable development (http://www.who.int/phe/en/).

[1] International Society for Environmental Protection (ISEP), Bechardgasse 24/12, 103 Vienna, Austria
Tel.: +43 (0)1 715 28 28, eMail: pillmann@isep.at

[2] DPSIR Driving force - Pressure - State - Impact - Response systems structure
http://glossary.eea.europa.eu/terminology/concept_html?term=dpsir
DPSEEA Driving force - Pressure - State - Exposure - Effect systems structure
http://www.integrated-assessment.eu/guidebook/dpseea_framework

There exists a multitude of environmental factors influencing human health.
Indicators for assessment of environmental effects on health are e.g.

Air quality	Climate change	Water and sanitation	Housing
Transport	Noise	Waste (solid, liquid)	Radiation
Food and food safety	Urban health	Hazardous substances	Occupational health
Tobacco smoke	Land use and urban planning	Food safety	Chemicals

Several combinations and extensions of this repertoire are depending on knowledge, personal interest and information availability. A list of further foci can be found in the Integrated Environmental Health Impact Assessment System where data, assessment techniques and models are assorted http://www.integrated-assessment.eu/sitemap.

2. Meta-model of the Relationship between Environment and Health

In the EnviroInfo conference Warsaw 2007 a closed-loop Generic Environmental Model Structure was presented, to visualize the interdependencies of man-made and natural environment and the role of environmental information. This model includes a part 'Environmental informatics' representing ICT applications for access to complex information contents. In the upper part of figure 1 this Meta-Model comprises the economic activities in the 'man-made environment' and the 'natural environment'. The systemic character is illustrated with process chains of resource use causing environmental stress. In the feedback environmental data is condensed to environmental information which infiltrates political, economic and social decision processes. This model improves the commonly used environmental stress and human responses model, often addressed as Driving force- Pressure-State-Impact-Response (DPSIR) model. A different structure called the DPSEEA structure (Driving force-Pressure-State-Exposure-Effect-Activity) is used predominantly in public health sciences (Fehr 2001, Pillmann 2007).

The lower part of fig. 1 zooms in the causal relationship between human health and the environment as a whole. From an environmental perspective, physical, chemical, and biological factors determine the individual health and have an essential impact on public health. The aggregation and analysis of environmental and health information with ICT methods and tolls supports the access to the complex information space.

3. Framework on Environment and Health Information

The co-operation between EU countries in the areas of environment and health started in 1989 when the WHO European Centre for Environment and Health was established. The Environmental Health Action Plan for Europe (1994), the Children's Environment and Health Action Plan for Europe (CEHAPE 2004) and the Intergovernmental mid-term review (2004) are results of this cooperation in Ministerial conferences. Consultations during CEHAPE guided governments to continue efforts in developing National Environment Health Action Plans (NEHAP's).

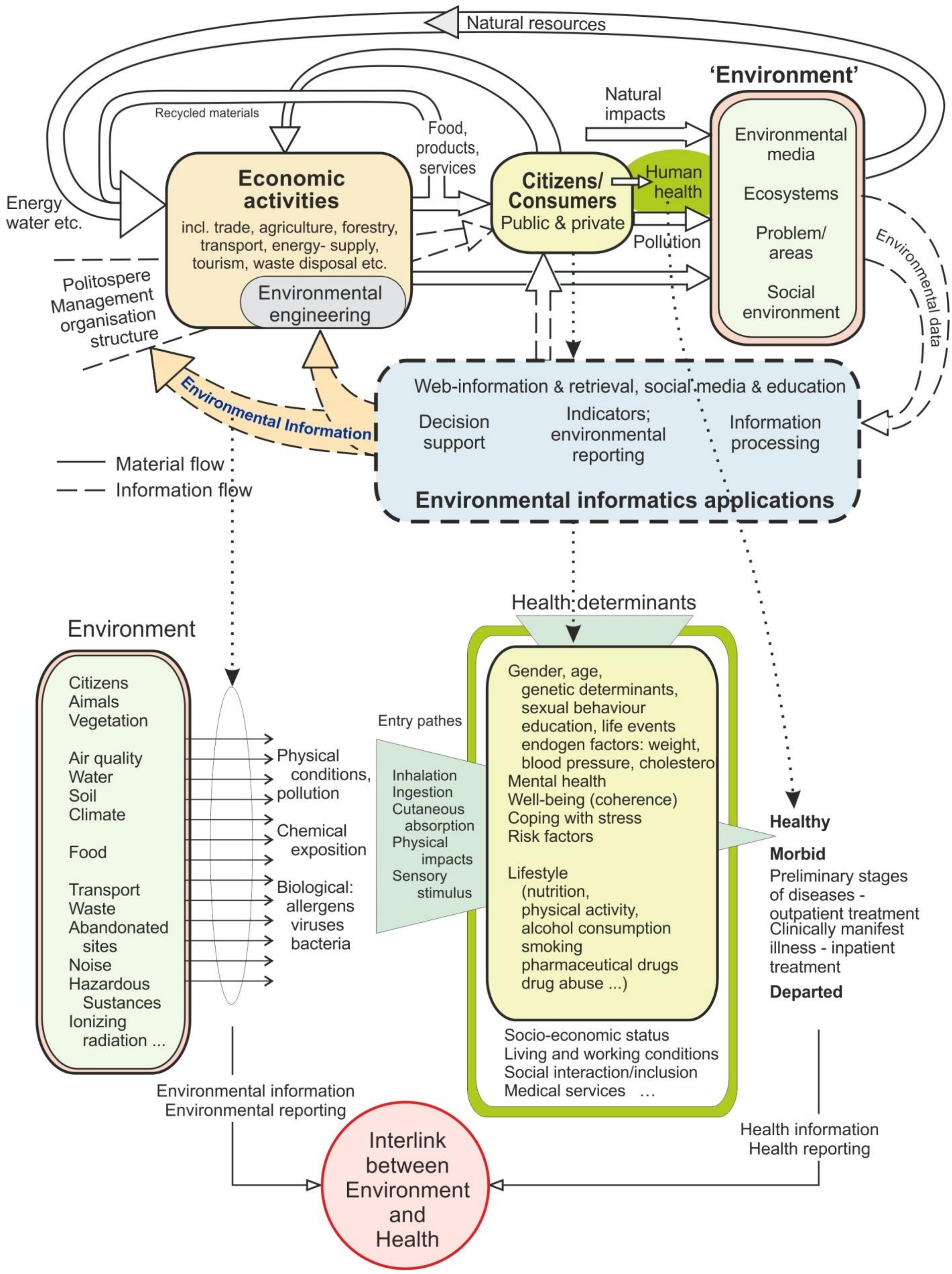

Figure 1
The role of informatics for determination of environmentally influenced health effects
(Source: Pillmann 2005, 2007, 2012)

In 2003 the European Commission implemented an EU Environment and Health Strategy which was adopted in 2004 together with the EU Environment and Health Action Plan (2004-2010). This plan includes the improvement of information on environmental health by developing environmental health indicators.

The last 5th Ministerial Conference on Environment and Health (Parma, Italy 2010) adopted a declaration to reduce the adverse health impact of environmental threats in the next decade.

The report 'Health and Environment in Europe: Progress Assessment' (2010) compared the results of integration of Environmental protection and health promotion of 42 countries' national policies on environment and health on the basis of Web questionnaires and the national plans.

WHO/Europe's databases are an important repository of health statistics. This information resource provides authoritative health data on the 53 countries in the WHO European Region. This enables comparative analyses of the health situation, identifying regional trends including key determinants of health (such as alcohol, tobacco and nutrition) http://www.euro.who.int/en/what-we-do/data-and-evidence.

Access to international environmental relevant health data allows the access to the international part of WHO's Web information the Global Health Observatory (GHO) http://www.who.int/gho/phe/en/index.html.

Another example, how health status indicators like e.g. the injuries rate of work places and of road traffic can be visualized provides the Direction General Health and Consumers with the tool Community Health Indicators (ECHI).

A bridge from data and information to human health builds the Environmental Impact Assessment (EIA) and the Health Impact Assessment (HIA). HIA sometimes is seen as part of the EIA. Another opinion is, that the practice and theory of HIA owes more to notions taken from healthy public policy and policy science than to EIA. However, both instruments are valuable for screening, scoping, risk assessment, decision support and the implementation of measures for the benefit of environmental sanitation in respect of health (Kemm 2006).

A study on Quantification of Environmental burden of disease associated with inadequate housing provides an example, how research results can be linked to an estimation of effects of the proximate surroundings of citizens http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf.

4. Embedding Health in Environmental Sustainability Research

Health data is basically stratified according to gender, age, disease groups, socio-economic attributes etc. In contrast, the collection and organization of specific environmental data is necessary in order to draw a comprehensive representation regarding health and the environment. In both fields ICT provides methods and tools to interlink information like databases, GIS and Web technologies and use the Web and mobile technologies for communication and dissemination of results.

To foster research activities in the field of "Environment and Health" a survey on ICT applications and research topics for environmental and human health is elaborated in the project 'ICT for ENvironmental SUstainability REsearch' ICT-ENSURE which was conducted by members of the Technical Committee Environmental Informatics. This project highlights potential ways of implementing ICT driven systems for a collaborative "Environmental and Health Information System". A survey on health and environment was elaborated in the ICT-ENSURE work package 8. The WP8 results give an overview of projects which aim at interlinking available health and environmental data in one system. This includes a timeline of the European and WHO implementation process of ICT for Health and Environment including action plans, involved institutions and developed information systems. Table 1 depicts a short insight of relevant institutions, information systems and action plans for the ICT development in the field of Health and Environment (Kerschbaum et al. 2010).

Table 1
ICT for Environment and Health. Sample of Information Systems and Action Programmes (Source: Kerschbaum et al. 2010 - modified)

WHO		**Period**
HFA 2000	Health for All (WHO health targets, comparability of indicators)	1978-1998
HEGIS	Health and Environment Geographical Information System	1991-2003
CEHAPE	Children's Environment and Health Action Plan for Europe	2004
ENHIS I+II	Implementing Environmental and Health Information System in Europe	2004 →
Databases	WHO/Europe’s portal to health statistics: Health for All DB	1970 →
ECEH Bonn	European Centre for Environment and Health, Bonn	2012 →
EU		
EEA	European Environment Agency	1993 →
Eurostat	Eurostat	1953 →
CORINE - AIR	Coordinated Information on the European Environment	1985-1995
ECHIM	Health Indicators and Monitoring	2005…2012
ECHIM/EUPHIX	www.healthindicators.eu	2009 →

The example of ENHIS

The European Environment and Health Information System ENHIS is an example of a multifaceted information container for Environment and Health information. It focuses on environment and health issues that are recognized for WHO as priorities. This includes water and sanitation, mobility and transport, air quality, food safety, housing, occupational hazards, chemical safety, ultraviolet and ionizing radiation. Based on available data, 22 core indicators describe these priorities by measuring pressure, exposure, health effects and action (http://www.euro.who.int/en/what-we-do/data-and-evidence/).

The example of ÖGIS

A comprehensive study on health and environment was the result of the inter-department cooperation at the Austrian Health Institute. The report “Environmental situation in Austria” in 9 volumes/37 authors/2.000 pages (ÖBIG 1989) and information based on continuous public health research results in the experts study ‘Health data and Environmental Data in Austria‘ (ÖBIG 1990). This report includes the essential parts needed for a systemic characterisation of the inter-relation between H&E. This includes

- Health statistics: common causes of death; cancer statistics, statistics from social insurance, preventive health examinations, child/mother examinations, accident statistics etc.
- Environmental data referring to: air , water, soil, vegetation, animals, food, ionizing radiation, noise, hazardous substances, indoor pollution, production and work place

addresses core areas (e.g. occupational medicine, biological monitoring, allergens, ionizing radiation, noise) and discusses methodological approaches of data fusion.

Due to the early stage of available Geographic information systems, there was a lack of regionalization of data. For this reason ÖBIG developed ÖGIS, a health information pseudo-GIS for social-epidemiology and health planning with

Epidemiology (death rate, cancer incidence, …)
Health planning, acute care (hospitals) and rehabilitation
Health planning – outpatient care etc.

This nowadays continuously updated information system is an example leading to the topic of a Shared Information System which is discussed as Shared Environmental Information System (SEIS) or more comprehensive as "Single Information Space in Europe" (SISE).

General Development

The complexity of building an information system for health and environment at the international level is apparent in the often disrupted development of such information systems. The most challenging requirements are the general lack of data, the missing comparability of data and the time-lag between environmental factors and their effects on individuals (see also Kerschbaum et al., Entleitner et al. 2010). Further there is a lack of financial subsidies caused by changes in political decision-making, changes in the staff working on larger IT systems and progress in IT systems per se. These are the most frequent reasons for interruption of information system development.

5. Conclusion

The information resources of environmentally co-determined health effects have developed to a high standard. The current politically stimulated scientific development points in the direction to enrich this resource with further detailed information. In contrast, there is a lack of structuring different noxes and understanding of process chains causing stress and diseases. The presented extended meta model of ICT-ENSURE is intended to identify further needs of research in environmental informatics to take a step towards SISE, a Single Information Space in Europe for the Environment. Some further challenges are

- to improve the empirical evidence of environmental influences on human and ecosystem health
- to foster interdisciplinary knowledge exchange up to legislation and
- to improve the interoperability of IT systems between research institutions, statistical entities and governments.

Acknowledgements

The authors thanks Elisabeth Mrakotsky for helpful hints and recognize several valuable information from Gerhard Fülöp (ÖBIG and Health Austria) who develops and extends continuously ÖGIS, the Austrian Health Information System.

Bibliography (all Hyperlinks from 28.7.2012)

Papers from EnviroInfo conferences see http://lit.ict-ensure.eu

Entleitner M. Wirl Ch., Kerschbaum J., Fülöp G. (200): ICT in Health and Environment in Europe with special focus on Austria. [EnviroInfo 2009, Part2, p 383-394] http://enviroinfo.eu/sites/default/files/pdfs/vol122/0383.pdf

Environmental burden of disease associated with inadequate housing (2011). Braubach, M., Jacobs, D.E., Ormandy, D. (eds.). WHO Regional Office for Europe http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf

Fehr R. (2002): Environmental Health Information Management: Selected Developments of Potential Relevance for the European Perspective [EnviroInfo 2002, Part1, p 133-143] http://enviroinfo.eu/sites/default/files/pdfs/vol105/0133.pdf

Fülöp G. (2010): Das Österreichische Gesundheitsinformationssystem „ÖGIS“. Einsatzmöglichkeiten und Erfahrungen 1991-2010. http://www.kbv.de/media/pdf/100329_georef._Daten_Fueloep.pdf

Health and Environment in Europe: Progress Assessment (2010). WHO World Health Organisation Europe. http://www.euro.who.int/__data/assets/pdf_file/0010/96463/E93556.pdf

Kemm J. (2006): Health impact assessment and Health in All Policies. In: Health in all Policies http://www.euro.who.int/__data/assets/pdf_file/0003/109146/E89260.pdf, p. 189-207.

Kerschbaum J., Wirl Ch., Entleitner M., Fülöp G. (2010): Health and Environment. Expert report for ICT-ENSURE WP8. Search in http://lit.ict-ensure.eu

MacDonell (2002): Integrating Environmental and Health Data to Assess Cumulative Risks. [Enviroinfo 2002, part 2, p.174-179]. http://enviroinfo.eu/sites/default/files/pdfs/vol106/0174.pdf

MacDonell (2011): NextGen Environmental Health Analysis: Community-Centric Approaches and Tools. [EnviroInfo 2011, Part 1, p 16-19]

MacDonell, Peterson J., Chang Y. et al. (2012): Preliminary Evaluation of Health Effects for Hypothetical Exposures to Contaminants from the Interim Waste Containment Structure. Argonne National Laboratory Environmental Science Division, Illinois. http://www.lrb.usace.army.mil/fusrap/nfss/nfss-feasstudy-techmemo-healthexp-2012-02.pdf

ÖBIG (1989): Umweltsituation in Österreich. 9 volumes, 2.000 pages: Luft, Wasser Boden, Pflanzen, Landschaft, Abfall, Chemikalien, Lärm, Tiere. Österreichisches Bundesinstitut für Gesundheitswesen, ÖBIG, Wien

ÖBIG (1990): Gesundheitsdaten und Umweltdaten in Österreich. Sluka F. (ed.) in cooperation with Katzmann W., Pillmann W. et al. Österr. Bundesinstitut für Gesundheitswesen, ÖBIG, Wien

Pillmann W. (2005): The Integration of Environmental Knowledge - Environmental Informatics Provides Information for Communication. [EnviroInfo 2005, p. 1-11]. http://enviroinfo.eu/sites/default/files/pdfs/vol111/0001.pdf

Pillmann W. (2007): Environmental System Models. From technical models to world models. Enviroinfo 2007 http://enviroinfo.eu/sites/default/files/pdfs/vol117/0009.pdf

Radkau J. (2011): Die Ära der Ökologie – Eine Weltgeschichte. Verlag C.H.Beck, München.

SEIS (2008); Towards a Shared Environmental Information System. Commission of the EC COM(2008) 46 final.

A.9. Chemicals in our life: Communication Strategies for Chemical Information under REACH (Knetsch, G)

Knetsch, G. (2012): Chemicals in our life: Communication Strategies for Chemical Information under REACH. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./ Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 119-124.

Chemicals in our life
Communication Strategies for Chemical Information under REACH

Gerlinde Knetsch[1]

Abstract

How Information Systems on Chemicals can provide a better understanding for environmental issues? Information and communication technology (ICT) plays an important role in the worldwide economy. Computational infrastructures and networks, with well documented data and information, underpin the possibilities to deliver target oriented messages to politicians and the public on a regional, national and global level. So, ICT has an impact for the well being of citizens in the world. Innovative technologies brings together various databases containing, for example, information about chemical substances and their properties, their behaviour and effects on the environment and in human beings. Consequently the issue of chemical safety is one of an innovation factor in our society, particularly from the point of view of health and environmental protection.

1. Introduction

The Federal Environment Agency (UBA) in Germany is one Competent Authority of the European Member States nearby other involved with the data management and assessment of chemicals. For more than 15 years the Agency has been experiences for design and implementation of complex data bases as well as the management of environmental and chemical data. Comprehensive and reliable information on the environmental properties of chemical substances and preparations is of immense importance for all areas of environmental protection and for averting danger in context of the chemical safety.

Regarding the information and technology aspects of the REACH-Regulations (EC) No 1907/2006 [EG, 2006] and No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labeling and packaging of substances and mixtures [EG, 2008], the Agency contributes their experiences in implementation of REACH-IT.

REACH is the Regulation in the European Union for Registration, Evaluation, Authorisation and Restriction of Chemicals. REACH places greater responsibility on industry to manage the risks that chemicals may pose to the health and the environment. In principle REACH applies to all chemicals: not only chemicals used in industrial processes but also in our day-to-day life, for example in cleaning products, paints as well as in articles such as clothes, furniture and electrical appliances. The concept of REACH in a short term means: No data – no market!

A very complex and extensive IT-system has been developed for managing all processes, the dossiers by their self, and the chemical data in special database so called IUCLID. A special focus of the approaches is the communication of non-confidential information on chemicals accessible to public. With respect to a user-friendly and informative way of providing environmental information to a wide community of users a harmonised, sound and current base of data and information on chemicals which can be updated and accessed at any time constitutes the basis for the provision of information to the public.

---

[1] Umweltbundesamt, Wörlitzer Platz 1, 06844 Dessau-Roßlau
email:gerlinde.knetsch@uba.de, Internet:http://www.umweltbudesamt.de;
http://www.reach-info.de

2. Material and Methods

The European Chemical Agency [ECHA, 2012] is the central management head quarter to tackle all processes for data management of the registration dossiers. The aim of the REACH-IT Project is to develop IT-support for the implementation of the REACH regulation and to fulfil their duties and obligations as defined under REACH. This IT – applications underpin the daily work of the Agency (ECHA) and the Member States Competent Authorities (MSCAs), enabling them, to communicate together with Industry [Bobersky & Top, 2010]. On the other hand the European REACH regulation is increasingly demanding the provision of non-confidential chemical information in a structured and searchable form for the public.

The data management and the handling of large data bases require the use of several tools and methodologies. To ensure support to all REACH processes, Information Technology tools have been developed to store and exchange information and data on chemicals [Knetsch, 2009]:

REACH - IT, the portal for the management of the workflows, including the management tools to control and operate the processes,

IUCLID 5 – the International Uniform Chemical Information Database.

This database includes information on the hazard properties of the substance, on the classification and labelling, and contains also their assessment of the potential risk presented by the substances, where required. This information is submitted to ECHA for several purposes, including establishing a centralized database which makes non-confidential data and information available to the public and to the authorities (ECHA, Commission, Member State Competent Authorities and Enforcement Authorities).

In the IUCLID 5 database information of the dossiers of chemicals are stored in a structured form based on the OECD Harmonised Templates. Figure 1 gives an overview about the chapters of a registration dossier for chemicals.

Figure 1
Chapters of a registration dossier according the
OECD Harmonised Templates
Source: OECD (2011)

This 'Information on Chemicals' section is the gateway to ECHA's public databases on chemical substances. The ECHA CHEM Portal[2] contains a plethora of information about chemicals in Europe. As of July 2012, the database contains 7660 individual substances as well as 30 300 dossier files submitted information on the properties of chemical substances.

3. Dissemination Portal for the public communication

3.1 ECHA CHEM

The ECHA Dissemination portal[3] provides electronic public access to non-confidential information on chemical substances manufactured or imported in Europe. The information originates from the registration dossiers, submitted by companies to the European Chemicals Agency (ECHA) in the framework of the REACH Regulations.

The information which ECHA makes available from the registration dossiers is listed in Article 119 of the REACH Regulation [EG, 2006], and includes:

1. The EINECS name, for substances listed in EINECS (European Inventory of Existing Commercial Substances),
2. The classification and labelling of the substance,
3. Physicochemical data concerning the substance and on pathways and environmental fate,
4. The result of each toxicological and ecotoxicological study,
5. Any derived no-effect level (DNEL) or predicted no-effect concentration (PNEC),
6. Guidance on safe use.

For certain information items, companies can request to not make the information available over the internet, if duly justified. When this possibility is not used, the following information on substances may be found in the portal:

1. The IUPAC[4] name of the substance,
2. The trade name,
3. If essential to classification and labelling, the degree of purity of the substance and the identity of impurities and/or additives which are known to be dangerous,
4. The total tonnage band within which a particular substance has been registered,
5. The study summaries or robust study summaries for environmental and human health endpoints,
6. The uses of the substance and the uses advised against.

In general, more information is available for chemical substances which are manufactured or imported in Europe in large amounts than for those in lower amounts.

[2] http://echa.europa.eu/information-on-chemicals/registered-substances

[3] http://echa.europa.eu/information-on-chemicals/registered-substances

[4] International Union of Pure and Applied Chemistry - Foster communication between chemists around the world

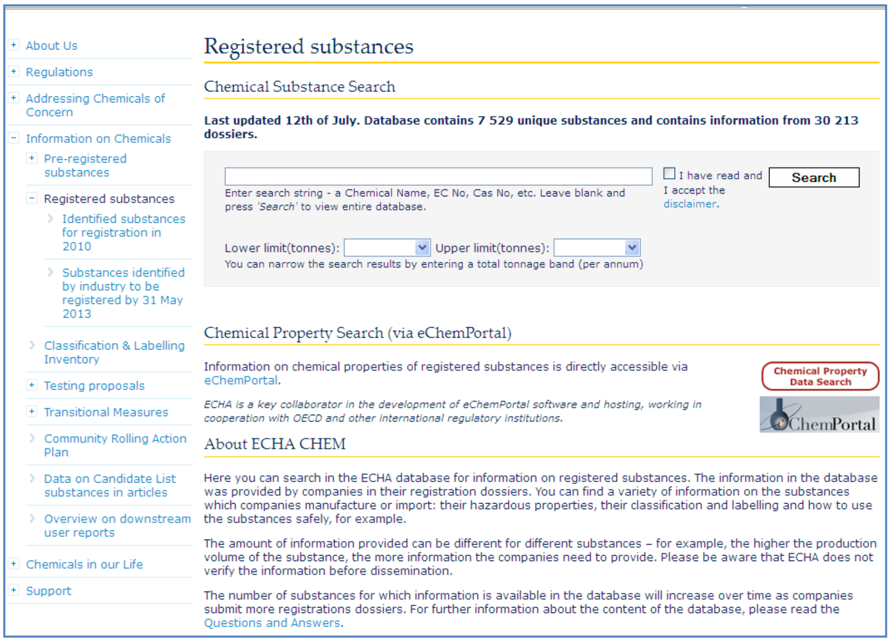

Figure 2
Chemical Substance Search on the ECHA CHEM Portal
Source: ECHA (2012)

The development of IUCLID 5 was performed under the terms of the W3C standards. Platform independence, ease of data exchange on a defined XML interface, supported by the exporter in IUCLID 5, and the consistently integration in a Java environment provide a future-oriented solution.

A web service-component of IUCLID 5 allows the integration in other applications. On the ECHA CHEM Portal there is a link to the eChemPortal of the OECD for the chemical properties research. The integration of the IUCLID database in this application of the OECD achieves a high degree of harmonization of the data towards exchange on chemicals.

3.2 e ChemPortal der OECD

The eChemPortal[5] –"The Global Portal to Information on Chemical Substances of the OECD" is a significant step towards achieving long-standing international commitments to identify and provide information on chemical properties to the general public. The main objectives of eChemPortal are:

1. To make this information on existing chemicals publicly available and free of charge.
2. To enable quick and efficient use of this information.
3. To enable efficient exchange of this information.

eChemPortal was developed in two phases. The first phase – launched in June 2007 - allowed users to search on substances by substance ID (name or identification number). Originally focusing on hazard information of existing chemicals, the scope was expanded to include new industrial chemicals, pesticides and biocides, risk assessments and classifications according to GHS. eChemPortal also offered links to a greater number of data sources.

[5] http://www.echemportal.org/echemportal/substancesearch/page.action?pageID=0

In the second phase – until now -eChemPortal was then re-developed to allow searches not only by substance name and identification number but also by chemical property. Users can select specific search criteria for chemical endpoint properties. As in Phase 1, search results offer links to the complete data set in the participating data sources' local systems. In order to provide this search, data sources submit and eChemPortal stores property data in the OECD Harmonised Template format. The templates ensure consistent reporting of test study report results in summary format across regulator programs. Corresponding XML schema enable electronic exchange between IT -systems. This is the link to the IUCLID-database including the same schema of the XML – OECD templates.

4. Conclusions and Outlook

The complex database of REACH is a project between the European Chemical Agency, the Member States of Europe and the Industry, financed by the European Commission. The development of the tools and the technical infrastructure has been highly influenced by the unique requirements of the several user groups. The discussion on possible approaches in the context of the applications REACh-IT and IUCLID 5 has been closely related to security aspects for confidential data.

On the other hand communication of non-confidential data via the ECHA CHEM Portal and the eChemPortal of the OECD is the straight forward way for a better understanding for environmental issues. The large number of existing commercial chemical substances and mixtures requires information and communication technology finding quickly and reliably information about the properties, use and application areas.

Various information systems manage chemical substance information and offer a wide range of users, valid data and information. This is associated with a high standard of data quality, data security and data management. Information systems on Chemicals play in future national and international context, an increasingly important role. The implementation of such chemical information portals for the general public takes a significant benefit. The "linked open data" approach benefits from such developments leads to an added value to information.

Bibliography

EG (2006): EG-Verordnung Nr. 1907/2006 des Europäischen Parlaments und des Rates zur Registrierung, Bewertung, Zulassung und Beschränkung chemischer Stoffe (REACH), zur Schaffung einer Europäischen Agentur für chemische Stoffe, zur Änderung der Richtlinie 1999/45/EG und zur Aufhebung der Verordnung (EWG) Nr. 793/93 des Rates, der Verordnung (EG) Nr. 1488/94 der Kommission, der Richtlinie 76/769/EWG des Rates sowie der Richtlinien 91/155/EWG, 93/67/EWG, 93/105/EG und 2000/21/EG der Kommission. Abl. Nr. L 369/1 vom 18. Dezember 2006.

EG (2008): EG-Verordnung Nr. 1272/2008 des Europäischen Parlaments und des Rates über die Einstufung, Kennzeichnung und Verpackung von Stoffen und Gemischen, zur Änderung und Aufhebung der Richtlinien 67/548/EWG und 1999/45/EG und zur Änderung der Verordnung (EG) Nr. 1907/2006. Abl. Nr. L 353 vom 16. Dezember 2008.

ECHA (2012): REACH-IT online zitiert unter: http://echa.europa.eu/reachit_en.asp, Helsinki.

OECD (2011): OECD Harmonised Templates for Reporting Chemical Test Sumies. http://www.oecd.org/document/46/0,3746,en_21571361_43392827_44169646_1_1_1_1,00.html

Boberski, C. & Top, M. (2010): REACH-Handbuch – Leitfäden, Checklisten und Dokumente für die praktische Umsetzung der neuen Chemikalienverordnung. Forum Verlag, Merching.

Knetsch, G. (2009): New IT-Trends in Collaboration and Networking for the Process of Registration, Evaluation, Authorisation and Restriction of European Chemicals. In: Proceeding of the European Conference on Towards eEnvironment Opportunities of SEIS and SISE: Integrating Environmental Knowledge in Europe, Prag.

A.10. Modular Information System on Chemicals – From Concept to Reality (Menger, M./Bandholtz, T./Ackermann, P./Jaspert, R.)

Menger, M./Bandholtz, T./Ackermann, P./Jaspert, R. (2012): Modular Information System on Chemicals – From Concept to Reality. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./ Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 125-132.

Modular Information System on Chemicals From Concept to Reality

Matthias Menger[1], Thomas Bandholtz[2], Patrick Ackermann[1], Rainer Jaspert[2]

Abstract

The Federal Environment Agency (UBA) in Germany is one Competent Authority of the European Member States nearby other involved with the assessment and authorisation of chemicals. For more then 15 years the Agency has been experiences for design and implementation of complex data bases as well as the management of environmental monitoring and chemical data. Comprehensive and reliable information on the environmental properties of chemical substances and preparations is of immense importance for all areas of environmental protection and for averting danger.UBA plays an important role in the enforcement of national and European environmental laws and regulations, for example in the field of industrial chemicals, plant protection products, medical and biocide products. If a risk to human health or the environment exists, UBA recommends conditions of use, propose restrictions or bans. For the scientific review and thus authorisation or restricition of this chemical substances or products an informations system based on a valide and accurat database is needed.This operational Information System Chemical Safety (ICS), developed and put on place for more then 15 years as a monolith with proprietary software, has been re-designed in a new modular information system. The paper 'illuminates' the technical solutions with the challenges and chances which has to be taken and offered, resulting in a highly flexible modular system to administer all important data and information on chemicals by using different software components/moduls connected with each other.

1 Introduction

The German Federal Environment Agency, "Umweltbundesamt (UBA)" maintains a heritage information system chemical safety since more than a decade, and is managing its accession since 2007. Since 2009 the technical implementation is in progress and moving towards production maturity, scheduled for autumn of 2012.

Last year's EnviroInfo hosted two related contributions: (Menger et al., 2011) discussed the sustainability aspects and (Stolle et al., 2011) got into technical details about the interfaces between the chemical part and the document/workflow-oriented components.

This year we will focus on modularity and change management ("From Concept to Reality"). The accession of an information system which has been coming to its technical limits provides new challenges. These limits should be eliminated, but the users have got used to them and their own workarounds. And, of course, the "new" system should function forever in eternal adolescence (but at least as long as the previous one).

---

[1] Federal Environment Agency, Germany
[2] innoQ Deutschland GmbH, Germany

Figure 1:
Logo of Unit IV2.1 Information System Chemical Safety

For such reasons the following issues has to been tackled:

- Flexibility of the stable data model (alone a paradoxon in itself) avoids new programming with each amendment of the application, meaning changes are made in the running system.
- Represent and support the technical requirements of four different regulatory processes that neither have a shared process model nor a shared terminology; allow a common harmonized view on the data/information without compromising the specific needs of each regulatory process
- Incorporate international standards for describing information, be compatible to existing important systems in the domain
- Support the whole regulatory process in the data handling, information extraction, administrative and workflow aspects and controlling
- Support data entry and research in an efficient way
- Intuitive and easy to use
- Migration of the legacy data without loss of information

With a detailed concept for the new ICS design, compiled by an other contractor (2007-2008) and the following representation in a technical model and its implementation as a fully functioning system, a very complex and challenging project had been born.

2 Main Components and Interfaces

The main components of the new ICS are:

- Chemical Data Management ("Stoffdaten"/ICS component),
- Document Management System (DMS),
- Process/Workflow Management (VBS).

During the review and authorisation processes selected document content of the submitted dossiers gets transferred into structured data, and later it may be included in a regenerated report document. This is why the data and document management must be close at hand at any time. The new system supports direct linking between documents, processes, and chemical information on the data set level. No user coming from some certain chemicals or processes will ever need to start a DMS and search for the related documents by some "magic number", they are just at hand, one click away. For an in-depth discussion of these interfaces see (Stolle et al., 2011).

In Figure 2 the main modules of the new ICS are illustrated – the Chemical Data Management ("Stoffdaten"/ICS component). the Document Management (DMS) and Process/Workflow Management

(VBS). The modular approach is reflected in Figure 3 - the data model of the moduls VBS and DMS in connection with the Management System of chemical substances.

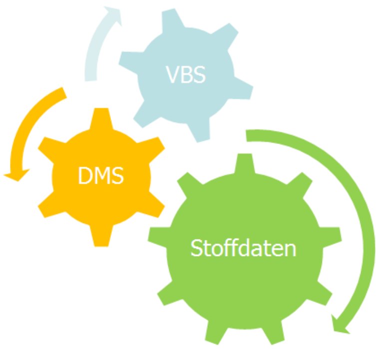

Figure 2:
Document Management (DMS), Process Management (VBS) and Chemical Data Management ("Stoffdaten"/ICS component) are the main components of the new ICS.

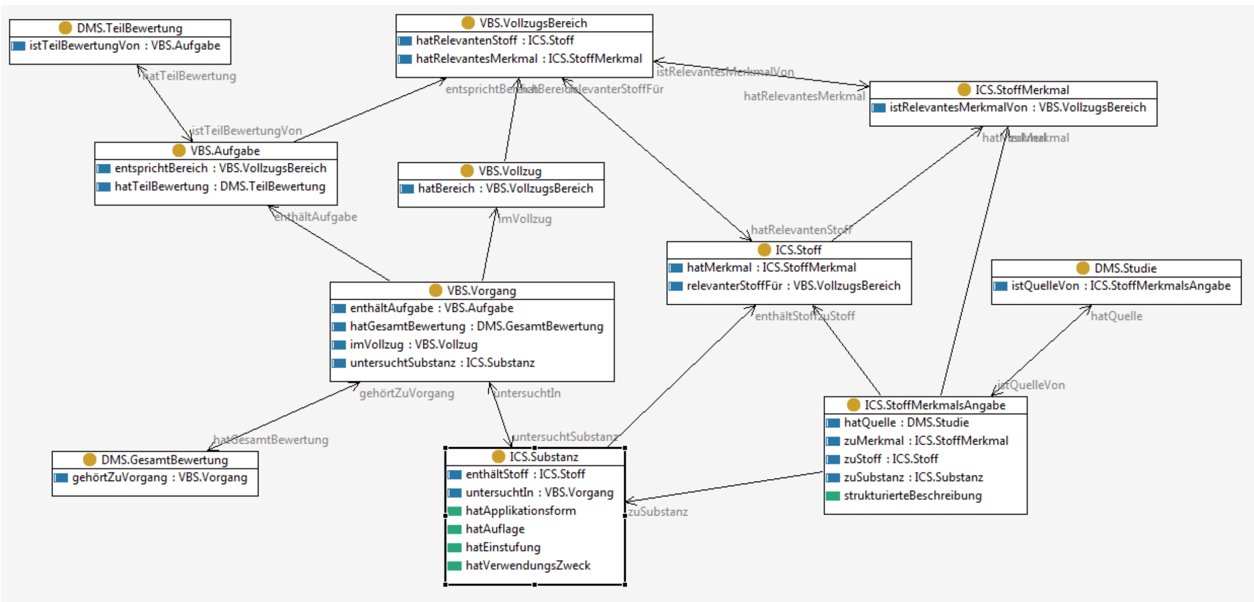

Figure 3
Cross-component information model

On a more technical level, this requires a convenient modularity of loosely coupled services as shown in Figure 4.

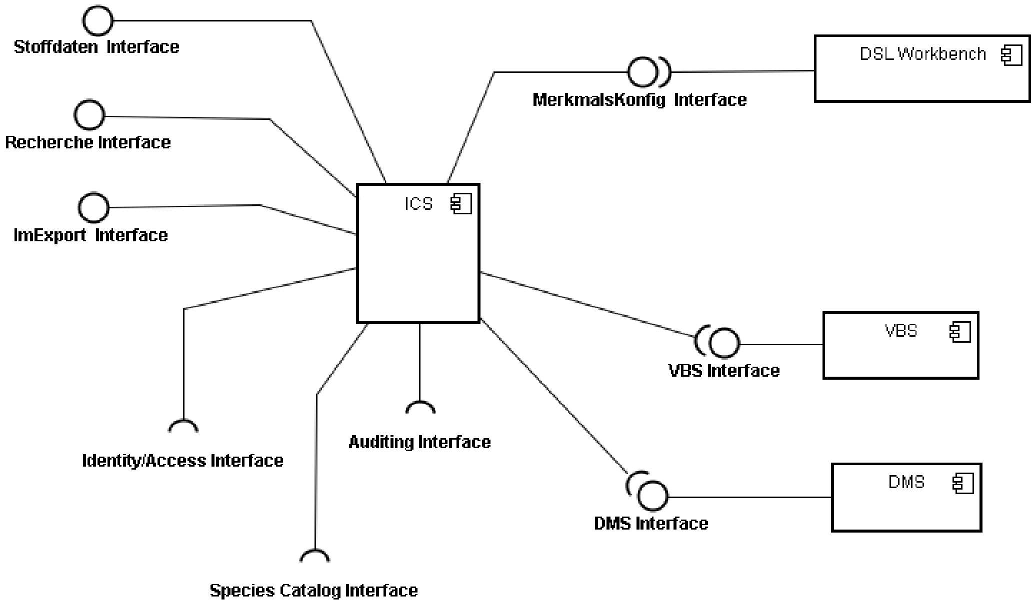

Figure 4:
Composition and interfaces of the overall system

The Domain Specific Language - DSL Workbench is an administrative tool to support data structure upgrades during runtime and has been covered more closely in (Menger et al., 2011). Besides integration of these four components, ICS provides several outgoing and incoming interfaces into the surrounding IT-landscape.

Strict interfacing always has to deal with redundancy. People will feel that they need to see some data in more than a single component and they want cross-component views. This could be addressed by a dedicated set of properties to be synchronized, each of them with an undoubtedly clear decision about which component is the one-and-only master.

All this results in a well-orchestrated protocol of acknowledgements and updates while users are making changes somewhere in the whole system. There is a large number of very small messages between the components, but there is no replication of large documents or data sets.

In this architecture we find a strict separation of concerns, coupled through documented interfaces which are based on open standards, where each component can be upgraded or replaced without endangering the running system.

These patterns are consequently applied to the ICS component itself (Figure 5). ICSService provides dialog interfaces suitable for common Web browsers. Data is included from its XML representation and enhanced by dialog function and style separately.

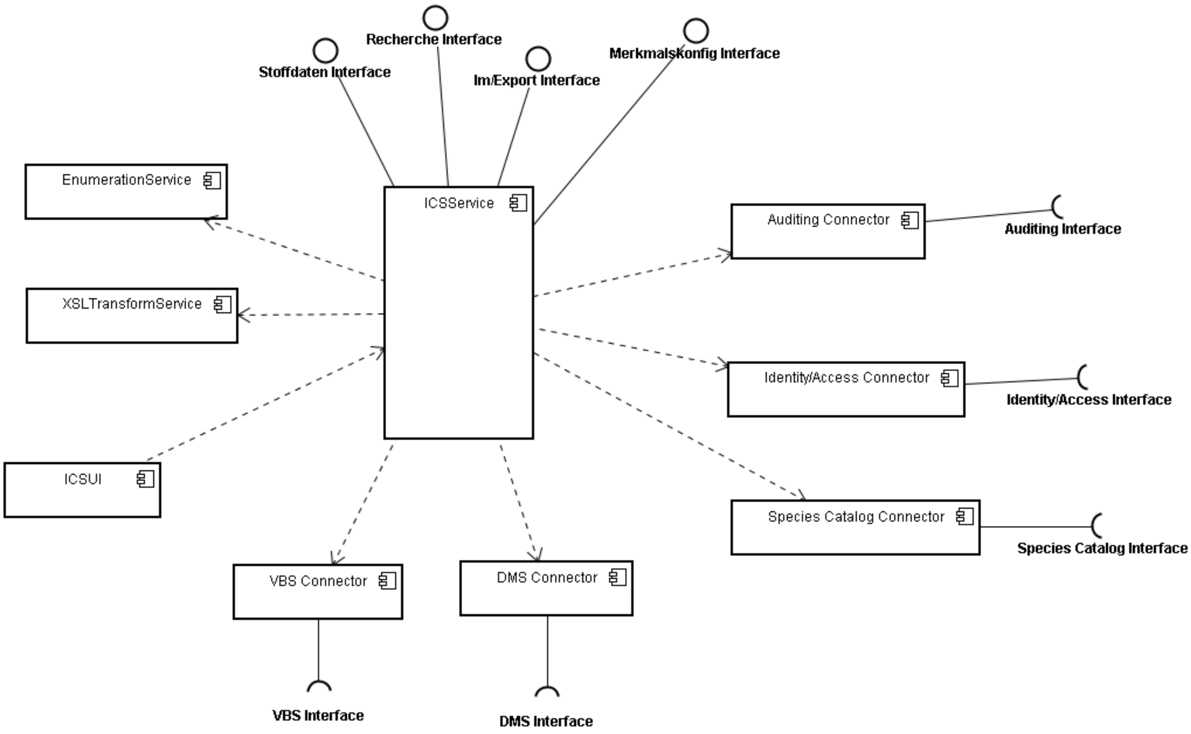

Figure 5:
Composition and interfaces of the ICS component

While ICSService certainly is the core engine of this system by means of complex functionality, the user may start working in the DMS and only eventually lookup some chemical data. This is completely transparent to the user.

There are some remaining differences in the look and feel of the interface. VBS/DMS are built with MicroSoft Sharepoint 2010, and we decided not to hide its native user interface. We wanted to have an autonomous VBS/DMS system that can be used on its own and – optionally – as part of the ICSnew System, or integrated in further systems in a similar way. The second decision was to prefer configuration over programming, and this results in domain administrators (not programmers) being able to maintain most of the system, but it also results in dialogs which really look and feel like MS Sharepoint.

On the other hand, we did not want to lose any freedom about the user interface design of the ICS component (Figure 6). The dynamic aspects of this user interface have been described in detail by (Menger et al., 2011).

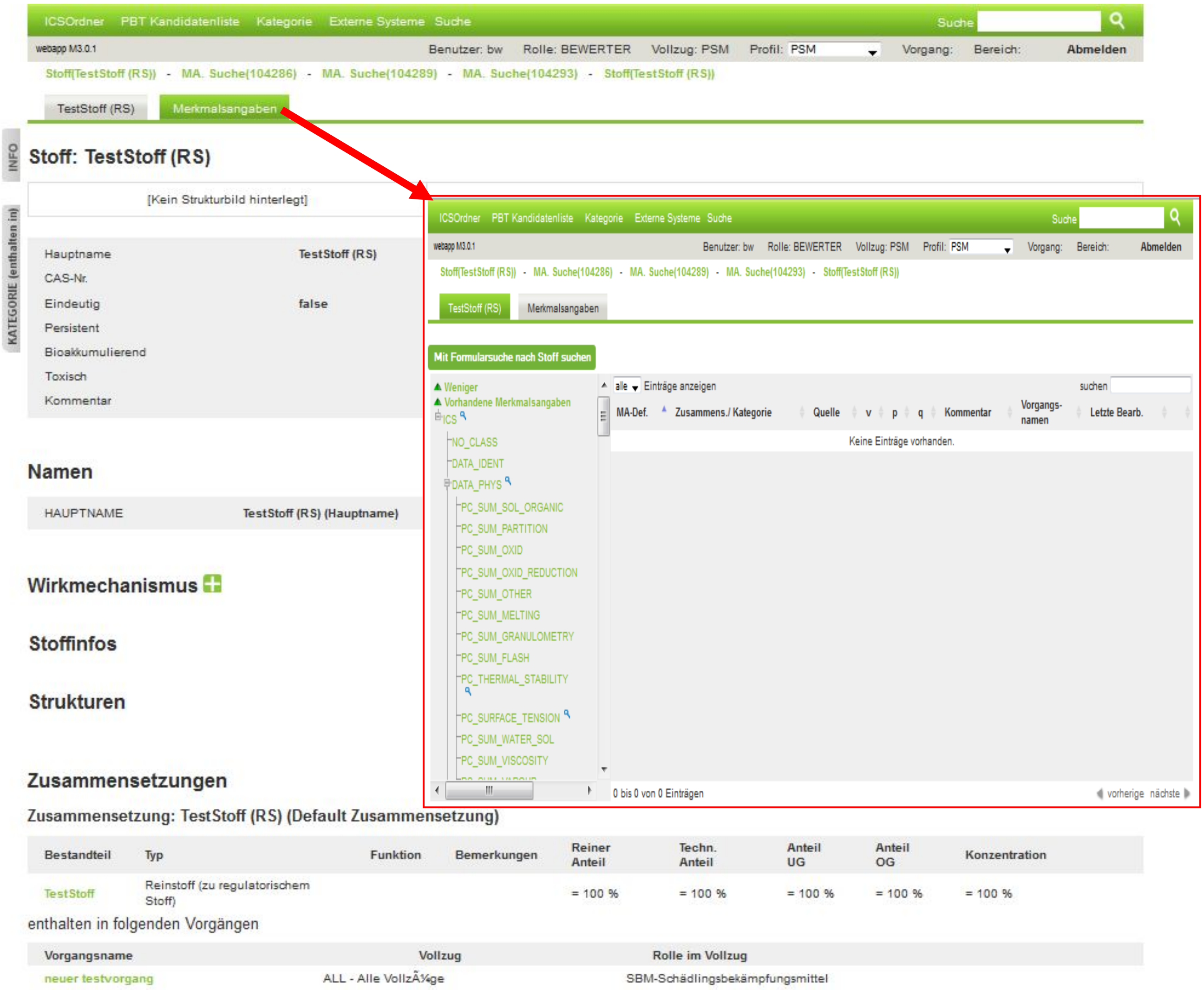

Figure 6:
Example of the ICS Web Client dialogues

3 Change Management

The technical challenges described in section 2 also had to face an organisational structure with only loose connections between the four regulatory processes. They all used to work on chemicals and partly on the same chemicals with different regulatory views, and every user should be able to benefit from what the others have done before. Just to remind that this information system is highly confidential and only accessible for defined internal user.

For new requirements as result of modifications within regulations or improvements of some restrictions the old ICS was extended by temporary stopgap solutions, e.g. office solutions, which have their own limitations. Nevertheless, all these existing solutions and associated or newly upcoming requirements has to be taken into account for the redesigned ICS to achieve an overall state of the art informationsystem on chemicals.

Overcoming old and very heterogenous workarounds users have been get used to has been the second most important challange. Providing a homogenous information system to all four heterogenous regulatory processes while keeping the specific requirements and views on chemical data and information is a continouing job. All the benefits of the new ICS has been discovered bit by bit and were strongly supported by the following strategies and of course personal engagement from all developers and project team members.

3.1 Iteration Strategy

While some of us developed detailed technical concepts about the strategic issues, others implemented an overall iteration strategy with rather short cycles right from the start. Each iteration was a prove of concept for one or two of these issues. Sometimes we had a fast success, and sometimes we needed a second attempt. Over time the resulting prototype gained some stability and complexity rather close to a test system. In the second half of the project period we needed to restructure some of the implementation, but not little of the code still originates from the early days.

Iterating in this way allowed for flexibility and visibility of each decision only short time after it has been made, and so we could avoid to get stuck in a waterfall dilemma.

3.2 Multiple Running Horses Strategy

Several times we suddenly noticed that someone was developing a tool with an obvious functional overlap. They needed a fast solution for something that ICSnew was intended to deliver only later.

We always tried to integrate such efforts even if this meant modifying our plans and developing more interfaces.

3.3 Multiplicator Strategy

Each iteration result was presented to pre-defined key users representing most of the the end users, with a growing number of users over time. These users were selected by the perspective organisational unit in the UBA, and they helped to understand the requirements and learned about our in parts unfamiliar concepts at the same time.

This helped to discover many details which had not been covered by the initial concepts at an early stage, and we established something like a core user group over time. Moreover, this clarification allows to identify potential requirements in the future and already test the system on its flexibility. Some twenty users have been involved in this way and have been trained on a near-production-ready test system. Now these key users will integrate their colleagues in this process till everybody is familiar with the new system before production starts.

3.4 Integrating Four Different Regulatory Processes

After having had the different organisational units in workshops, we found that each of them followed a different pattern even when they all work on chemical safety.

They were used to different tools, they still have a slightly different terminology, and they have a slightly different view on the structure of substances. Whenever we had everything settled for one of the units, some other unit told us we were completely wrong. But none of these units was wrong.

We found that they had to learn more about each other, and they will have to get used to a system terminology that tries to merge all the concepts.

3.5 Break the Heritage Strategy

People who were used to the old ICS heritage had found a way to deal with its limits and disadvantages. Finally they could get what they wanted, and got used to *how* they can get it. After several years it may be difficult to imaging a completely different approach that eliminates those limits and disadvantages right from the start.

Others who worked with MS Excel and MS Word have developed complex table structures over time, and they find it hard to move over to a database system with rather similar table structures which cannot be controlled by these users to the same extent.

In both cases the new ICS offers convenient solutions both in task navigation and structural flexibility, but both needs to be unveiled. There are new user roles in a more formally controlled way, with a transparent separation of concerns.

People have to learn that software development is not focussed on preserving the user's habits in first place. Some of the new patterns are simply better (at least on the second look …), and some simply have to be accepted due to resource limitation when it comes to individual tailoring of the user experience.

3.6 Going Life with a Small Bang

Everybody agrees the upgrading of a critical piece of software with a "Big Bang" will fail. There is only one approach that is even worth: allowing a prolongated transition phase with two active systems (old and new) that need to be synchronised day by day before a small bang.

4 Summary

The project took us quite a long journey from the initial draft to a running system which we had not quite anticipated before. In three years' time just for the technical realisation both users and developers shared a continuous learning curve with an evolving understanding of each other, negotiating old habits and innovation, hard-coding and configuration to succeed at last. Maybe this is why serious IT projects are nearly almost late, but it is worth to take the time in the end.

Bibliography

Menger (et al.) (2011): Matthias Menger, Patrick Ackermann, Thomas Bandholtz, Rainer Jaspert, Antoine Logean: Building a Sustainable Information System in the Domain of Chemical and Biological Safety. In: EnviroInfo, Ispra (Italy) 2011.

Stolle (et al.) (2011): Christopher Stolle, Kurt Sparber , Matthias Menger. Integrating Workflow and Document Management with Domain Applications by Using MS SharePoint 2010 with REST Interfaces. In: EnviroInfo, Ispra (Italy) 2011.

A.11. BIG Kosmos: a cosmos of chemical information (Kuyken, W.)

Kuyken, W. (2012): BIG Kosmos: a cosmos of chemical information. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./ Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 133-135.

BIG Kosmos: a cosmos of chemical information

Wendy Kuyken[1]
(revisited by Johan Broeckx)

1. Who we are?

BIG was founded in 1979 as a support center on dangerous goods to provide information to fire brigades when confronted with incidents involving chemicals. Today we are a highly qualified knowledge center on dangerous goods with clients that vary from governmental institutions, emergency services, SME's and large multinationals from all over the world. As an emergency center BIG can be reached 24 on 24, seven days a week. We provide training and consultancy, but also tailor-made solutions in allowing companies to be compliant to regulations related with dangerous goods. Currently our BIG team consists of a highly trained staff of 44, all experts in different fields ranging from transport regulation, REACH and CLP, toxicology, ecotoxicology, database development and so much more. (www.big.be)

2. Feeding BIG Kosmos

The heart of BIG is a cross linked database containing information on more than 50 000 substances and mixtures. The database is multilingual and per product file more than 2000 properties can be entered. The data can be accessed through different parameters such as CAS No., EC index number, formula, … and through about 600 000 synonyms. In order to feed the database information is gathered, evaluated and validated through an ISO certified quality system. The strength of the database is that all information as well legal as coming from client or other literature sources is linked on substance level. The database is structured in a way to allow for easy extractions of the data in order to integrate them in management systems like SAP-EH&S. In order to be able to do this every single item in the BIG Kosmos is coded and linked to an extensive library of language catalogues containing standardized sentences. This allows for easy translation and consistency in the wording of hazards, risks, measurements, …

2.1 Literature study

Before a substance or mixture can be added in the database a full literature study is performed by BIG to gather, evaluate and validate the relevant data on that substance or mixture. In the procedure several double checks are included to be able to guarantee a high level of quality of the data eventually being put in BIG Kosmos. In figure below you can see the flow of how a literature study is performed:

[1] BIG vzw, Technische Schoolstraat 43A, B-2440 Geel, e-mail: wendy.kuyken@big.be

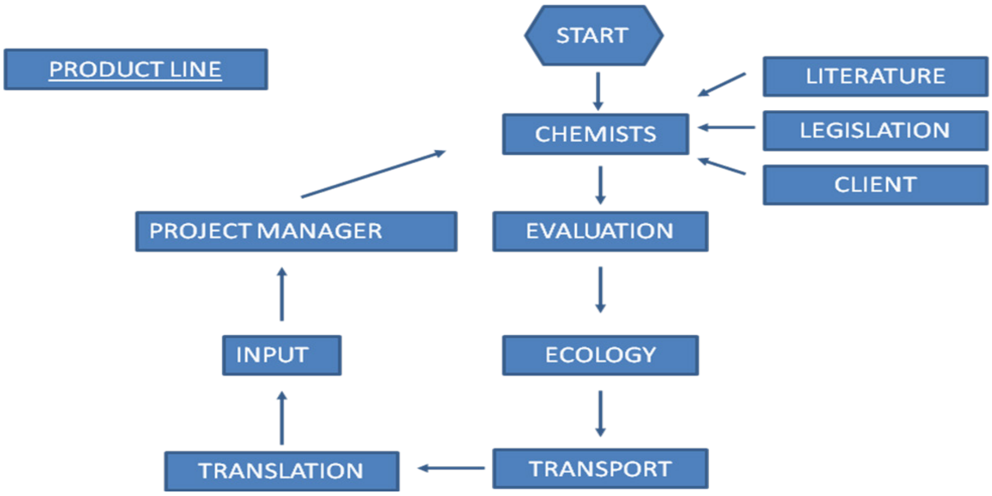

Figure 1
flow of literature study at BIG

2.2 Updating Kosmos

One of the difficulties in maintaining a database is keeping the data up-to-date, especially when dealing with crucial information as is present in the BIG Komos. Whenever legislation changes, criteria change, classifications are amended it is imported that these are also as soon as possible realized in BIG Kosmos and distributed to our various users. This is in particular challenging since most legislation is published completely in HTML or PDF-files. In some case IT can provide an outcome, but in some it is plain human labor that has to deduct all information from the legislation and adapt it to a format that can be implemented in BIG Kosmos.

The format has to allow for an easy way to check and compare the different versions (updates) of legislations. BIG therefore tries to create standardized structures and procedures to handle updates of country dependent and other relevant data.

3. Output

With the BIG Kosmos as heart of our system we can provide different products and services for our users. A highly valued output of the BIG Kosmos is the BIG Kaleidos, a yearly extraction of the mother database that is issued out every year containing information on 20 000 substances and mixtures in 13 languages. The selection of the substances for the BIG Kaleidos is done based on the high volume list in combination with the substances that are enumerated in the ADR with UN number.

Listening to the needs of our audience we also developed a limited version of this; limited in the set of substances, the data and languages. We also released a mobile version on pocket PC or windows mobile phone that is very much appreciated by intervention services like fire men or first responders in general. We are now developing a web based solution of this application as well to be able to accommodate all operating systems.

On request of the first responders we also developed an intervention card for the 1080 most common substances (most dangerous and those most commonly used and transported) and published those in a book. For industry we developed and published a similar bookwork where the card is adapted to the needs of occupational safeguarding, meaning that it contains clear pictograms and guidelines for the people on the floor. The fact that BIG has its own IT department allowed us to offer these things also in an electronical form through DDS. DDS stands for Document Distributing System and is a web application to allow companies to manage and distribute documents.

BIG stands true to its core business and therefore focuses on quality data on chemical substances and mixtures. We acknowledge that there are several high standard EHS management systems on the market to make life of the EHS manager easier, like the EHS module of SAP. However each of these systems is dependable on the data put into the system to be able to guarantee a decent output and here often lies the problem for the EHS manager. Not only is putting in the data a very time consuming affair, but he is also depending on the information provided by its suppliers. It is no need to say that often this information provided is unclear, inconsistent or not up to the standard required. Here BIG can help. The data structure of the BIG Kosmos is mapped to the data structure of the system, the user can select clusters of substances that he wishes to add to his system and the data is uploaded. The number of updates a year can be set in accordance with the needs of the client.

BIG also provides tailor made finished documents for clients like product safety cards or Safety Data Sheets.

4. Safety Data Sheets

SDS'es or Safety Data Sheets have since long time been the ideal tool to communicate on the hazards of the chemicals used and how to need to handled by industrial and professional users. Unfortunately studies showed that the majority of SDS'es were not up to standard. Therefore when introducing a whole new Regulation concerning chemicals it was decided to also add new guidelines on how to draw up an SDS. So in the REACH Regulation No. 1907/2006 Annex II describes in detail what needs to be in the 16 sections of the SDS. Meanwhile the UN developed the Globally Harmonised System for classification and labeling of chemicals or GHS. GHS was developed to work away the differences in classification in the different parts of the world. The UN text consisted only of guidelines that needed to be implemented in the different legislations around the world. The EU implemented the GHS via Regulation No. 1272/2008, also known as the CLP Regulation. In order to incorporate CLP and the extra data generated by the REACH Regulation in the form of exposure scenario's into the SDS, EU issued out Regulation 453/2010 amending the Annex II of the REACH Regulation.

At BIG we specialize in drawing up Safety Data Sheets conform the EU regulations. The new regulation offers plenty of challenges. BIG has developed a template and export tool to draw up extended SDS'es for Pure substances and mixtures. The challenges not only lie in the vast quantity of data that needs to be on the SDS, but also the complexity of the data and the need to tackle the differences in the data depending on the source. For instance the classification of a substance now cannot be taken from one single source anymore, since through the obligations in REACH new data is discovered or generated through studies and tests, which needs to be taken into account when evaluating what is delivered by the supplier or what can be found in the list of harmonized classifications in the regulation.

A.12. Dioxine Database – An Approach of Congener-Specific Data Analysis (Gärtner, P./Knetsch, G./Raab, G./Nouhuys, J. v.)

Gärtner, P./Knetsch, G./Raab, G./Nouhuys, J. v. (2012): Dioxine Database – An Approach of Congener-Specific Data Analysis. In: EnviroInfo 2012 – Man, Environment, Bauhaus – Light up the Ideas of Environmental Informatics (Part 1), Arndt, H.-K./Knetsch, G./ Pillmann, W. (Eds.), Shaker Verlag, Aachen, S. 137-142.

Dioxin Database – An Approach of Congener-Specific Data Analysis

Philipp Gärtner[1], Gerlinde Knetsch[1], Gregor Raab, Jo van Nouhuys[2]

Abstract

Dioxins and PCBs are persistent organic pollutants (POPs), a term used to designate organic chemicals that accumulate in the bodies of humans, animals and plants and that have the potential to be transported across long distances. POPs may cause disturbances of the immune system, nervous system, reproductive functions and enzyme systems, with all its consequences. It is very important to monitore the contamination of the environment, foodstaff and feeding staff with dioxins permanently. As a measure to counteract the risk posed by POPs to man and the environment, a number of international environmental treaties have been agreed to in the past. For the sake of public information about the contamination of man and the environment by POPs, the Federal Environment Agency collects data on the concentrations of dioxins and others POPs in the Federation and Laender cooperation Dioxin Information database www.pop-dioxindb.de. The data base includes a lot of metadata e.g. sampling site, sampling method, analysis method, laboratory data, and the analytic results with specific congeneres. An online site with information and evaluation of the data is available. On the other hand an directly request to the database is possible getting timetrendas and congenere profiles.

1 Introduction

The establishment of the dioxin database began in 1991 with the decision of the 37th Conference of the Ministry of Environment. In it, the Federal working group on dioxins (AG Dioxine) was assigned with the central documentation and evaluation of results from research programs regarding the impact of persistent organic pollutants (POPs). The database is administrated by the Federal Environmental Agency and the Federal Office for Consumer Protection and Food Safety. On the basis of documented results from measurement programs to the compartments soil, air, water and waste, biota, preparations and products, forward-looking statements about contaminations are deduced.

"POP-DioxinDB" - the portal to data and information on the subject of Persistent Organic Pollutants (POPs) is an Internet application for centralized documentation of screening programs for dioxins in the environment. Federal and state agencies (Länder) are involved partners, they provide data, reports and analyzes of POPs. The constant exchange of data between federal and state agencies (Länder) was governed in 1997 by an administrative agreement.

The E-Government application informs the public on a bilingual website about current events, new scientific knowledge, political information, but also about results of analyzes of data from the dioxin database. The application is an instrument for the fulfillment of national and international reporting obligations under the POPs Convention (May 17, 2004).

Creating a Web Service for the Dioxin Database was part of the Project of the cooperation agreement on Environmental Information Systems (KoopUIS). The Federal Environment Agency and the Bavarian State Ministry of the Environment and Public Health supported the project financially and conceptually. In addition, the Federal Agency for Consumer Protection and Food Safety joined the project with its profes-

---

[1] Federal Environment Agency, Germany www.umweltbundesamt.de
[2] Condat AG, Germany http://www.condat.de/

sional expertise in the subject of foods. The Web Service provides worldwide access to the central Dioxin Database in the Federal Environment Agency. A unique feature of this Internet application is the combination of data from different environmental compartments, the feed and food sectors, and human exposure in a common database system. The current system supports a complex algorithm to evaluate various toxic equivalents and features that characterize a compartment.

Figure 1
Multilingual Web-Service "POP-DioxinDB"

2 The Data

To capture the ubiquitous contamination of the environment by dioxins, samples of soil, emissions, food and feed products, breast milk, plants and animals and many other compartments are merged within the information system. The data set of 47,000 samples with many individual measurements of various pollutants also facilitates an automated calculation of toxic equivalents (according to guidelines of the WHO and NATO certain pollutants are multiplied by a predetermined value and set in relationship with the highly toxic 2,3,7,8-TCDD, which is represented with the factor 1). The content is provided group-oriented, for example to generate professional background information for chemists and the public, special congenere data for researchers. A link to the metadata of the Joint Substance Data Pool of the German Federal Government and the German Federal States (GSBL) is associated with the substance spectrum of the Dioxin Database.

The stored data is used for the evaluation of the background contamination of the environment; on this basis updated reports on concentrations of dioxins and PCBs are generated. In investigating the causes of dioxin contamination numerous entry and transfer paths as well as chemical interactions are verified with modern statistical methods. Recent events have shown that new information technologies can assist in finding the root cause of pollution most efficiently.

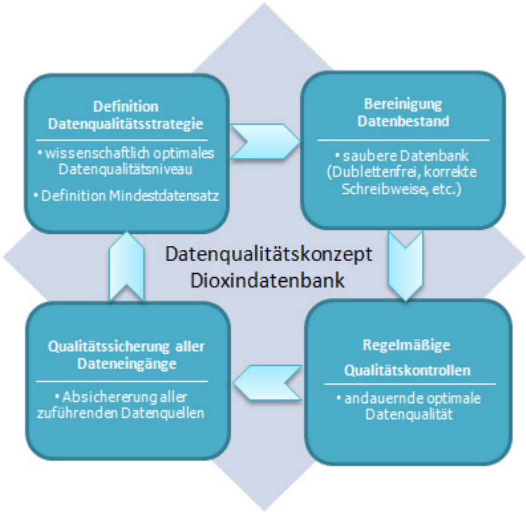

Figure 2:
Data quality concept of the POP-Dioxin Database

The data of POPs is stored in a congener specific manner. This approach allows finding pattern of typical congenere profiles. In Figure 3 one is seen a congenere profile for the six Indicator-PCBs of fish. The data is compiled in such a manner to get a feeling of the typical scatterplot for the compartments in the environment [Knetsch, 2012].

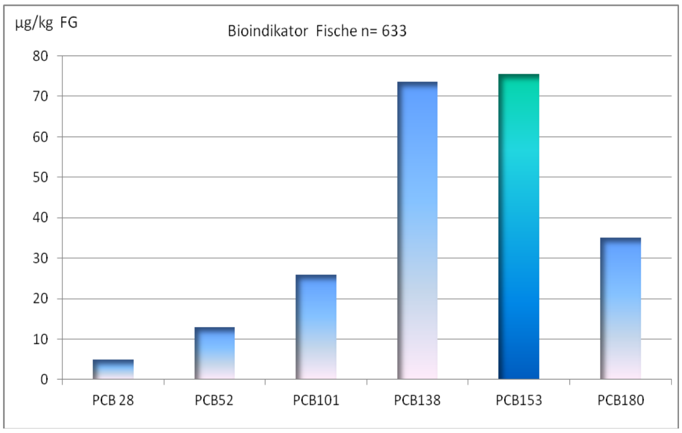

Figure 3:
Congenere Profile of the Indicator PCBs for fish, Source: Knetsch 2012

3 New Challenges

Repeatedly occurring in recent years, dioxin scandals motivated to take advantage of the growing and comprehensive data set of the dioxin database not only for reporting, but for "cause of persecution", for example to find possible causes of a food contamination.

Conceptually, the database - project is based on the approach of the congener-specific monitoring. This approach provides the foundation for building a congener-pattern database. Chemical compounds with the same structure form a so-called congener-pattern, an indication of similar sources. The patterns are generated according to complex mathematical instructions from the individual measured values of a dioxin sample and converted into statistical graph representations.

Dioxins - specifically PCDDs, PCDFs, and dioxin-like PCBs - are multi component mixtures. Each of them has a specific pattern in the combination of individual components and they are toxic in different ways. For example: in total there are 209 different PCB compounds. To assess the toxicity of dioxins, toxic equivalency factors are used for calculations. The individual congeners are classified in relation to the most toxic substance called 2,3,7,8-TCDD ("Seveso poison").

The found dioxin patterns in acute strain situations can give indications of possible pathways and causes, compartment specific congeners are stored as reference profiles in the database (see Figure 3) to discovered similarities to this point - an important move to reduce harm for the environment.

The database already supports the comparison of patterns of the archived sample inventory. As a result of the latest project this will be done by an automated procedure of modern information technologies.

3.1 Technical Realization

With the help of a software module, the R scripting language will be interpreted within the Web application. In this way profiles are analyzed according to current mathematical and statistical approaches. As mentioned, the database stores reference profiles for different environmental compartments. The comparison of a contaminated sample with a reference profile is automated by scaling the reference sample, with the aim of being able to visualize both profiles optimally in a statistical diagram. Thus similarities and differences between both profiles become visible. Based on the profiles, the evaluation of similarities or differences of two profiles can be determined by the user.

In addition, upon request, a mathematical assessment carries out the similarity of profiles to provide the user an assisting tool for the evaluation. This allows users to choose the most similar reference profile from a statistical point of view. The statistical methodology is seen as an aid in comparing profiles, it provides valuable information, but it does not replace the visual comparison of the profiles by the expert. The professional review is in the responsibility of the user. This functionality is provided to the expert group of users over a powerful, scalable web services platform. By integrating high-performance math libraries, large amounts of data can be computed without user limitations. Conceptually, the data documentation is based on the approach of the congeners. This consensus of the working group on dioxins for more than 15 years has become the foundation for building a congener database.

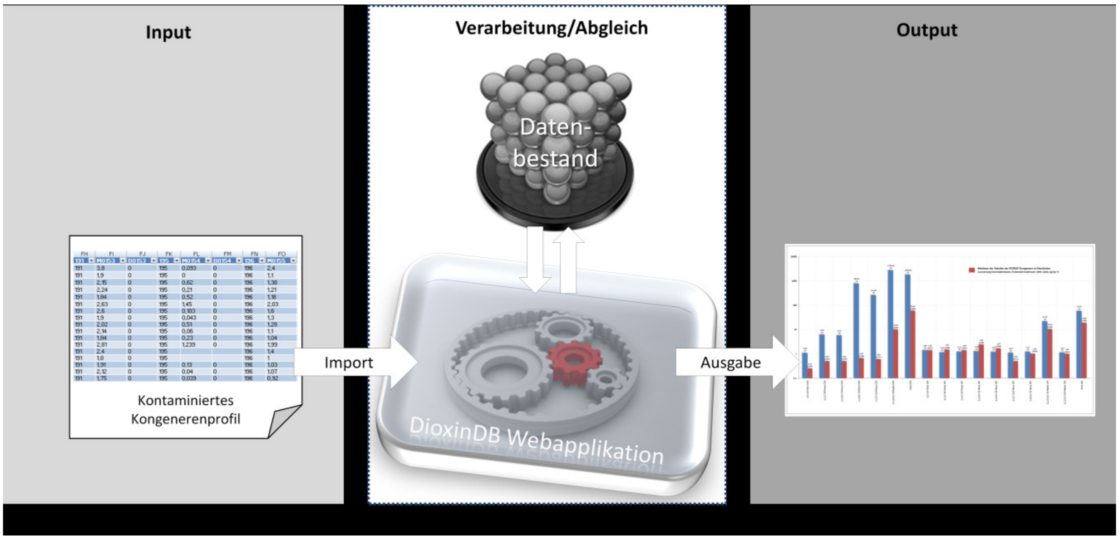

Figure 4:
automated similarity calculations

3.2 More Flexible Data Research, Statistical Analysis and Visualization

The above requirements and the existing weaknesses of the current application trigger demands for greater flexibility of the research opportunities for experts. The search criteria are not predetermined; it’s a variable search system. Similarly, highly flexible statistical analysis and presentation options are desired. The requirement for "ease of use combined with high flexibility" is often an irresolvable contradiction in software development: the more flexibility, versatility and functionality are offered by a software product, the more complicated is the navigation.

In designing the new web application for the dioxin database this contradiction has been resolved by using an “ease of access”-approach.In order to rid users of the need to acquire in-depth knowledge of the technical data model, a prior task of the project was to determine the information they need and simplify it as much as possible. The service is designed according to professional criteria, the interface provides the full definition of requests, allowing users to customize structure and filter conditions.

When configuring the module selection, relevant sections of the data model are determined and provided for the definition of requests; this is already a very important step of abstraction. Then the definition provided for the selection is grouped and provided with additional meta information. Also, the configuration can be adapted during operation, which ensures a high degree of flexibility and expandability. To allow users an on-the-fly research with few mandatory fields, but also offering an individual and enhanced search, preset catalogs are available that can be expanded as required.

The modular design of the systems facilitates a gradual development of complex systems. Perspectively, the UBA will seek to expand the application to use new parts. In addition to this technological basis, several applications in a uniform appearance are configured modular and provided for specific target groups. The creation of services and interfaces to integrate applications into a service-oriented architecture are integral components of the Eclipse technology. Thus, the multiple functions of the dioxin database, e.g. the export or the generation of statistical diagrams can be used by other external UBA IT-systems.

The methodological and technical approach to design the research component is configurable; it allows users to implement flexible and demand-oriented research, statistical analysis and presentation of results without knowledge of the technical data model.

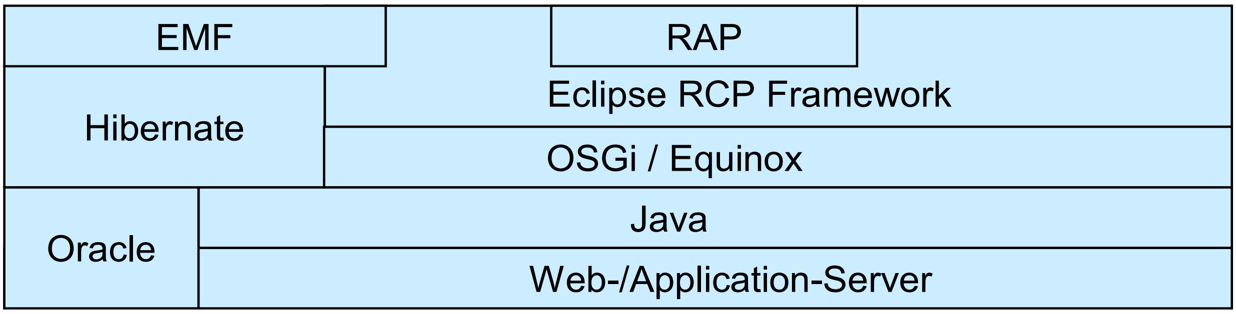

Figure 5:
software architecture

This approach can be applied generally to other databases in the Federal Environment Agency and facilitate database searches. At the same time it supports the experts in the "publication" of data in an open data policy of the agency.

4. Summary

The project is still running and we are trying to work out a scientific tool that is really useful for harm prevention when it comes to contamination situations by organic substances. Still there is a lot to do, in the next steps we are planning to merge the world of mathematics (R) with our new service to provide state-of-the-art statistics over a web application.

Bibliography

Nielsen, J. (2000): Systematischer Ansatz des Internetdesigns (Erfolg des Einfachen), Markt und Technik, 2000.

Rudlof, C. (2006): Usability Engineering (Handbuch Software-Ergonomie), UKPT, 2006

UBA (2012): WebSite http://www.umweltbundesamt.de/chemikalien-e/pops.htm

UBA (2012): WebSite http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do?nodeIdent=2379

Filzmoser, P.; Garrett, R. G.; Reimann, C. (2005): Multivariate outlier detection in exploration geochemistry (Computional Geosciences), 2005

Knetsch, G. (2012): Integratives Auswertungskonzept von Umweltdaten mit dem Ziel der Ableitung einer Bilanz für polychlorierte Biphenyle in der Umwelt, In: Jochen Wittmann, Bernd Page (Hrsg): Simulation in Umwelt- und Geowissenschaften, Reihe: Umweltinformatik, 2012.