Multilingual education of students on a global scale and perspective—international networking on the example of bioindication and biomonitoring (B&B technologies)

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REVIEW ARTICLE

Multilingual education of students on a global scale and perspective—international networking on the example of bioindication and biomonitoring (B&B technologies)

Bernd Markert · Edita Baltrėnaitė · Ewa Chudzińska · Silvia De Marco · Jean Diatta · Zahra Ghaffari · Svetlana Gorelova · Jorge Marcovecchio · Guntis Tabors · Meie Wang · Naglaa Yousef · Stefan Fraenzle · Simone Wuenschmann

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Abstract Living or formerly living organisms are being used to obtain information on the quality of the general health status of our environment by bioindication and biomonitoring methods for many decades. Thus, different roads toward this common scientific goal were developed by a lot of different international research groups. Global cooperation in between

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various scientific teams throughout the world has produced common ideas, scientific definitions, and highly innovative results of this extremely attractive working field. The transdisciplinary approach of different and multifaceted scientific areas—starting from biology, analytical chemistry, via health physics, up to social and economic issues—have surpassed mental barriers of individual scientists, so that "production" of straightforward common results related to the influence of material and immaterial environmental factors to the well-being of organisms and human life has now reached the forefront of international thinking. For the further sustainable development of our common scientific "hobby" of bioindication and biomonitoring, highest personal energy has to be given by us, being teachers to our students and to convince strategically decision makers as politicians to invest (financially) into the development of education and research of this innovative technique. Young people have to be intensively convinced on the "meaning" of our scientific doing, e.g., by extended forms of education. One example of multilingual education of students on a global scale and perspective is given here, which we started about 3 years ago.

Keywords Intercultural side effects · Multilingual education · Transdisciplinary · Bioindication/biomonitoring · Environmental pollution · Globalization

Introduction

Processing and transferring information is crucial for achieving a sustainable, high-level way of living, besides addressing the problems related to use of matter and energy (Fraenzle et al. 2012; Markert and Fraenzle 2007; Markert et al. 2009). Information means to convert hitherto unknown matters into pieces of established knowledge; the Latin verb *informare* means to educate, to give things some shape.

Different forms of networking procedures and methods to exchange information in between scientists and characterized international relevance exist all over the world. One relatively new method is the intensive use of multilingual education of students, which will be explained on the example of the global and effective distribution of bioindication and biomonitoring, so-called B&B technologies, below. The multilingual education project started by the request of a French colleague—already about more than 5 years ago in 2008—asking for a translation of a fundamental review article on B&B technologies (Markert et al. 2003) added by case studies of French-speaking nations (Herzig and Bieri 2002). The French version was translated by professional native speakers in Paris and finally published by a national French journal (Markert et al. 2010). At this moment, the description of the scientific use of B&B methods has been available by an additional language. It was especially asked for by students and scientists working in the field of environmental pollution who are mentally more positive influenced and motivated to deal with and understand these modern and innovative technologies by their own national language.

In "Future promotion for an increased global use of B&B technologies by enhanced educational, research, and financial resources", we will report on the extension of this project by translation of the same article mentioned above (review article added by case studies) but translated by highly motivated young scientists of other nations including national publications. Given examples are published in Chinese (Mandarin), Farsi, Lithuanian, and Polish languages.

A transdisciplinary approach of such network is an additional guarantee that a biotechnological development—based on bioindication and biomonitoring methods—will be further on intensively and scientifically forced in the future. The use of clever and intelligent approaches—on a rationally and emotionally likewise based common platform—are essential for motivation and education in monitoring the state of our environment.

First, some general aspects will be given about the scientific content of the multilingual papers before they were handled by young scientists; the final results of this project and will be discussed in "Future promotion for an increased global use of B&B technologies by enhanced 22 educational, research, and financial resources."

Some general aspects of bioindication and biomonitoring

As compared to "conventional" means of measuring emissions, doing bioindication or biomonitoring involves much less expenditure in personnel than, for example, running a deposition sampler. Hence, bioindicators can be employed throughout large areas provided that the organisms are sufficiently far spread and abundant to enable investigations which can cover entire countries or even continents which could be done otherwise only when accepting very high demands of work and money (Fraenzle et al. 2012; Markert et al. 2003).

Using one or several different organisms (plants, animals, fungi) for the purposes of estimating environmental burdens bring about yet another advantage: beyond statements on the very organism which is embedded in some ecological niche within an ecosystem, the analytical data obtained can be

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integrated into a more comprehensive biological system. Thus, beyond obtaining data from the very bioindicator, ecologically relevant statements are feasible concerning larger parts of the biocoenosis due to the biotic interactions which interconnect them, unlike using direct physico-chemical methods.

Markert et al. (1997, 2003) gave an exact and meanwhile generally accepted definition to discern bioindication and biomonitoring as follows:

Bioindicators are organisms or communities of organisms whose content of certain elements or organic compounds and/or whose morphological, histological or cellular structure, physiological–biochemical processes, behavior or population structure(s), including changes in these parameters, supply information on the quality of the environment changes. Bioindication compares relative data of information (e.g., on contamination) to each other.

Biomonitors are organisms or communities of organisms whose content of certain elements or organic compounds and/or whose morphological, histological or cellular structure, metabolic–biochemical processes, behavior or population structure(s), including changes in these parameters, supply information on the quantity of the environment changes. Bioindication compares absolute data of information (e.g., on contamination) to each other.

During active bioindication (biomonitoring), bioindicators (biomonitors) bred in laboratories are exposed in a standardized form in the field for a defined period of time. At the end of this exposure time, the biochemical or pathophysiological responses provoked (e.g., chlorosis or leaf damage caused by ozone in white-clover test) are recorded or the pollutants taken up by the organism are analyzed. In passive bioindication (biomonitoring), organisms already occurring naturally in the ecosystem are examined for their reactions.

Common requirements on bioindicator/biomonitor organisms are given as follows:

- High abundance (frequency)
- Widespread (global, euryoecious)
- Easily identifiable
- Easily available
- Analytically accessible, low detection and determination thresholds with current analytic technology
- Accumulation of pollutants

Use of mosses as a practical example

As an example, the use of mosses as bioindicators/biomonitors for controlling the atmospheric deposition of chemical elements will be shown. Clear-cut examples of application can be found

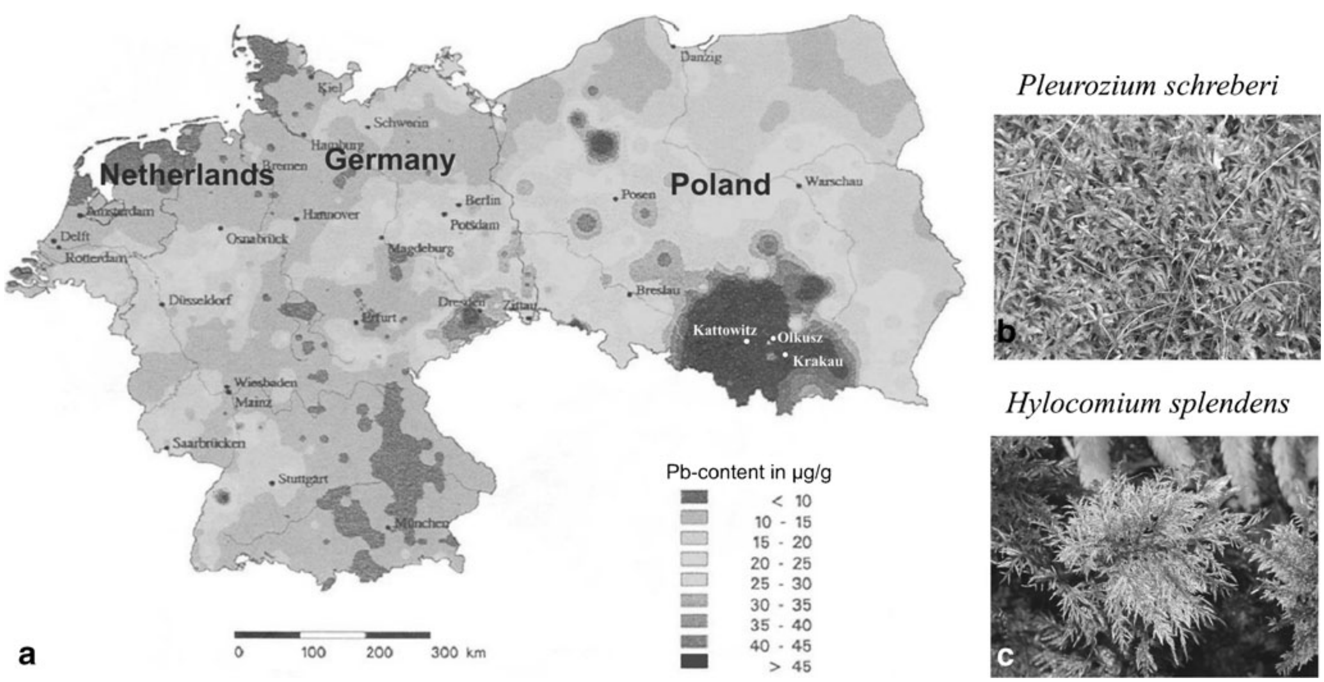

Fig. 1 **a** This map gives Pb contents in moss species from different countries (Netherlands, Germany, and Poland). The moss samples were taken from 1990–1992 (Herpin et al. 1996); Mosses (only two moss species of totally four of the overall European program are shown as examples, **b** *Hylocomium splendens* and **c** *Pleurozium schreberi*) as bioindicators/biomonitors for controlling the atmospheric deposition of different chemical elements. Photographs of **b** and **c** are courtesy of Wikipedia. (fig. from Fraenzle et al. 2012)

for instance in papers by Berg and Steinnes (2011), Berg et al. (1995), Harmens et al. (2010) and Jeran et al. (2004). Mosses are characterized by

- A primitive morphology
- Absence of a cuticle cover
- Having no roots but rhizoids
- Having no water-conducting system
- Ready accumulation of airborne pollutants
- Wide distribution
- Easy to collect

Mosses are suited for this kind of analytical work because they lack a cuticle interface. In higher plants, the cuticle limits evaporation, protecting plants against drought. Further, the cuticle is an obstacle to the uptake of water and salts dissolved in it via the surface of a plant. Because there is no cuticle in mosses, these plants can directly take up water and minerals required for growth via their leaf surfaces and thus do need neither "genuine" (i.e., mineral absorbing) roots nor a water conduction organ system. Thus, the "primitive" structure of mosses, as compared to more differentiated vascular land-borne plants, becomes a distinct advantage in pollutant level observation, with the pollutants likewise taken up directly through the surface are unprotected by a cuticle (Fraenzle et al. 2012).

In general, the results obtained indicate what is expected from good moss material chosen for biomonitoring: efficient absorption, high contribution to uptake from atmospheric as opposed to soil sources, and high retention of at least heavy metals. However, the results do suggest differences in the adsorption/retention abilities of moss growing in different locations (Tabors et al. 2004).

In addition to lacking a cuticle, mosses are distinguished by a rather large resistance towards enhanced levels of various anthropogenic air pollutants, permitting their use in rather highly polluted areas also (unlike lichens, Loppi et al. 1994). With many species being far spread (living in quite different regions), larger areas can be monitored using a given species (Markert

Table 1 Multilingual publications on bioindication and biomonitoring issues in chronological order

Language	Authors	Title	Published in
German	Markert, B.	Einsatz der Bioindikation und des Biomonitorings zur Umweltüberwachung, Definitionen, generelle Aspekte und Anwendungen	Markert, B., 2001, MS version, unpublished[a]
English	Markert B., Breure T., Zechmeister H	Definitions, strategies and principles for bioindication/ biomonitoring of the environment	Markert B, Breure T, Zechmeister H, eds. 2003. Bioindicators & Biomonitors. Elsevier, Amsterdam.
French	Markert, B., Wünschmann, S., Herzig R, Quevauviller P.	Bioindicateurs et biomoniteurs; Définitions, stratégies et applications	Techniques de I´Ingenieur, 2010, P 4170, 1–16.
Lithuanian	Markert B., Wünschmann S., Baltrėnaitė E.	Aplinkos stebėjimo naujovės. Bioindikatoriai ir Biomonitoriai: Apibrėžtys, Strategijos ir Taikymas	Environmental Engineering and Landscape Management 2012a, 20, 3, 221–239.
Polish	Markert, B., Wünschmann, S., Diatta, J., Chudzińska, E.	Innowacyjna Obserwacja Środowiska: Bioindykatory i Biomonitory: Definicje, Strategie i Zastosowania	Environmental Protection and Natural Resources 2012b, 53, 115–152.
Chinese	Markert B., Wang, M., Wünschmann, S., Chen, W.	生态环境生物指示与生物监测技术研究进展 (Bioindicators and Biomonitors in Environmental Quality Assessment)	Acta Ecologica Sinica, Elsevier 2013a, 33, 1, 33–44.
Spanish	Markert, B., Wünschmann, S., Marcovecchio, J., De Marco, S.	Bioindicadores y Biomonitores: Definiciones, Estrategias y Aplicaciones	Marcovecchio, J., Freije, R., eds., 2013. Bioindicadores y Biomonitores Procesos Químicos en Estuarios
Persian	Markert B., Wünschmann S., Ghaffari Z	مشاهده‌ی نوآورانه‌ی محیط زیست؛ شناساگرها و ناظران زیستی: تعاریف، راهبردها و کاربردها	Journal of Environmental Management and Planning 2013b, Vol. 2, 95–110.
Latvian	Markert B., Wünschmann S., Tabors, G.	Inovatīvie vides novērtējumi. Bioindikatori un biomonitoringi: definīcijas, stratēģijas un programmas	2013, in prep.
Russian	Markert, B., Wünschmann S, Gorelova S	Биоиндикаторы и биомониторы: определение, стратегии и применение. Использование древесных растений для биомониторинга и биоиндикации окружающей среды.	2013, in prep.
Arabic	Markert, B., Wünschmann S, Youssef, N.	اتعايف : ا اقبة ابيئية ا بتكة ا ؤ ات و ا و ا د احيوية وا ا ت اتيجيات وا تبيقات	2013, in prep.

[a] Used as original source for all other translations into languages mentioned in Table 1.

et al. 2011). Owing to their large surface/volume ratio, mosses will readily accumulate elements (Tabors and Lapina 2012). When transferred into the plants, pollutants get bound to cell walls. Thus, mosses accumulate substances throughout the entire period of vegetation growth, providing information on an averaged pollution situation integrated along the period of growth. Thus, mosses are perfectly suited for monitoring pollution which is due to atmospheric deposition.

The results from chemical analysis are converted into multicolor maps of pollution using Geographic Information Systems, such as that for lead given in Fig. 1. As final output, these investigations compare relative analytical data of element concentrations given by a bioindicator species like mosses.

For quantitative results of transferring bioindicative into biomonitoring data, the values can be converted into quantitative deposition rates for chemical elements found in mosses using relatively simple mathematical formulas (Berg et al. 1995). Today, comparable investigations of calculating a relationship in between bioindicators used and diseases are described i.a. in Nimis et al., (2008), Wappelhorst et al., (2000) and Wolterbeek et al., (2010).

Future promotion for an increased global use of B&B technologies by enhanced educational, research, and financial resources

Besides doing first-class research on bioindication and biomonitoring, utmost efforts must be dedicated to educate young students in a way that they become strongly motivated to move into our specific working field. Considering the respective psychological terms and conditions, it does not only mean to act as a professional teacher by giving information on the scientific topic

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Markert B, Wang M E, Wünschmann S, Chen W P. Bioindicators and Biomonitors in Environmental Quality Assessment. Acta Ecologica Sinica, 2013, 33(1): 0033-0044.

环境质量评价中的生物指示与生物监测

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摘要：通过比较生物指示与生物监测技术和仪器分析技术的分析过程及原理，结合北京市土壤中土壤脲酶与土壤重金属含量之间的相关关系的案例，及生物指示与生物监测技术在水生生态系统及大气污染研究中的应用状况，系统阐述了生物指示与生物监测技术研究的发展历程、研究前沿及发展方向。指出定量校正及不同学科与地区的科学团队的合作是生物指示与生物监测技术研究中需要克服的关键问题，并提出生物指示与生物监测技术研究的目标是整合不同学科的研究方向，为人类健康与环境安全的保护与预测提供技术支持。

关键词：生物指示与生物监测；环境污染；学科整合；人体健康与环境安全

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فصلنامه مدیریت و برنامه ریزی محیط زیست | سال دوم شماره ۱ بهار ۱۳۹۱

مشاهده‌ی نوآورانه‌ی محیط زیست، شناساگرها و ناظران زیستی: تعاریف، راهبردها و کاربردها

ترجمه ای از مقاله‌ی
Innovative Observation of the Environment

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ترجمه: زهرا غفاری*

دانشجوی کارشناسی ارشد علوم محیط زیست، دانشکده محیط زیست و انرژی، دانشگاه آزاد اسلامی، واحد علوم و تحقیقات

چکیـــده

چند سالی است که برنامه‌های کلاسیک نظارت بر محیط‌زیست به تدریج مکمل اقدامات گذشته شناساگرهای زیستی می‌شوند. در اینجا تحقیقاتی که بر روی موجودات زنده و یا بقایای آنها (ازجمله کودهای گیاهی) صورت گرفته است که در جهت نشان دادن وضعیت کیفی (شناساگر زیستی) و یا کمّی (نظارت زیستی) محیط‌زیست مورد استفاده قرار می گیرد. این گونه تحقیقات ارائه کنندهٔ اطلاعاتی در رابطه با ظرفیت زیست محیطی یک منطقه در برهه‌ای از زمان و تغییرات محیط‌زیست درگذر زمان(تحلیل روند) می‌باشد. برنامه‌های کلاسیک شناساگر زیستی اغلب با مشاهده و اندازه ...

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APLINKOS STEBĖSENOS NAUJOVĖS. BIOINDIKATORIAI IR BIOMONITORIAI: APIBRĖŽTYS, STRATEGIJOS IR TAIKYMAS[1]

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Santrauka. Jau keletą metų „klasikinės" aplinkos stebėjimo programos yra papildomos bioindikacinėmis priemonėmis. Atliekami gyvųjų organizmų arba jų liekanų (pvz., durpių) tyrimai, siekiant nustatyti aplinkos būklę kokybiniu (bioindikacija) arba kiekybiniu (biostebėsena) požiūriu. Taip gaunama informacijos apie regiono aplinkos problemas tam tikru metu arba aplinkos pokyčius laikui bėgant (tendencijų analizė). Taikant klasikinę bioindikaciją dažnai stebimos ir organinės, ir neorganinės cheminės medžiagos, matuojamos jų koncentracijos tiksliai nustatytuose bioindikatoriniuose augaluose arba gyvūnuose (taip pat ir žmogaus organizme). Kalbant apie analizines procedūras ir rezultatus, pastebimos panašios bioindikatorių tobulinimo ir naujų analizinių metodų plėtojimo tendencijos. Bioindikacijos plėtrai vykstant jau beveik 30 metų, išskirtinos tam tikros tolesnės plėtotės tendencijos: 1) atliekant išsamius elementų biologinės sistemos tarpusavio sąsajų tyrimus dažniau pasirenkama kelių elementų bendroji analizė; 2) daugiau dirbama (analizinis darbas) sprendžiant naujų rūšių atsiradimo klausimus siekiant pereiti prie aplinkos mokslų, nukreiptų į tikrąjį poveikį; 3) daugiau dėmesio skiriama kompleksiniams bioindikaciniams metodams, nes esant daugybei aplinkos stebėsenos problemų, pavienis bioindikatorius daug vertingos informacijos neteikia. Kompleksinės koncepcijos, pavyzdžiui, daugiaženklės bioindikacijos koncepcija, remdamosi antrosios kartos bioindikacijos metodika, numato paprastų aplinkos apsaugos prevencijos priemonių. Šiame straipsnyje pateikiami tyrimų, atliktų Lietuvoje, pavyzdžiai iliustruoja kelis naujus aspektus formuojant kompleksinę bioindikacijos koncepciją.

Reikšminiai žodžiai: aplinkos stebėsena, biostebėsena, bioindikacija, elementų biologinė sistema, kompleksinė biostebėsena, daugiaženklės bioindikacijos koncepcija.

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OCHRONA ŚRODOWISKA I ZASOBÓW NATURALNYCH NR 53, 2012 R.

Bernd Markert*, Simone Wünschmann**, Jean Diatta***, Ewa Chudzińska****

INNOWACYJNA OBSERWACJA ŚRODOWISKA – BIOINDYKATORY I BIOMONITORY: DEFINICJE, STRATEGIE I ZASTOSOWANIA[1]

INNOVATIVE OBSERVATION OF THE ENVIRONMENT – BIOINDICATORS AND BIOMONITORS: DEFINITIONS, STRATEGIES AND APPLICATIONS

Słowa kluczowe: biomonitoring, bioindykacja, Biologiczny System Pierwiastków, zintegrowany biomonitoring, Koncepcja Bioindykacji Wielowskaźnikowej (MMBC).
Key words: Biomonitoring, Bioindication, Biological System of the Elements, Integrative biomonitoring, Multi-Markered Bioindication Concept (MMBC).

Streszczenie

Od wielu lat pomiary z zakresu bioindykacji są uzupełnieniem „klasycznych" programów monitorowania środowiska. Badania nad żyjącymi organizmami lub ich szczątkami (np. torf) są obecnie wykorzystywane w celu określenia stanu środowiska pod względem jakościowym (bioindykacja) lub ilościowym (biomonitoring). Dostarczają one elementarnych informacji o stopniu zanieczyszczenia środowiska danego regionu, zarówno w konkretnym mo- ...

Fig. 2 Excerpts of abstracts about bioindication and biomonitoring studies published in **a**. Chinese (Markert et al. 2013a), **b**. Persian (Markert et al. 2013b), **c**. Lithuanian (Markert et al. 2012a), and **d**. Polish (Markert et al. 2012b) journal—peer reviewed, translated, assisted, and co-authored by young scientists itself, but to convince students mentally, for instance by oral and written information transfer by communication which occurs during delivering some lecture, that this approach is most meaningful and most rewarding.

An impressive and comparative study within the Open-Air-Laboratories-Project (OPAL) by Davies et al., (2011) and related to the overall public community showed that monitoring the state of the environment using plants, animals, and fungi has proved to be very popular with the public in UK. Participants from all ages, backgrounds, and abilities were actively involved. OPAL provides evidence to support Mellanby's (1974) suggestion that the potential of public observations in preserving and improving the environment should receive more attention. Further benefits are accrued through improved well-being (Bird, 2007; Barton and Pretty 2010; WRI, 2005) and a positive contribution to sustainable development (ODPM, 2005).

The same behavior in using languages is typically developed in between talks of students to students or students to teachers and vice versa. Within their nation, the use of mother language is often preferred. Translated into conditions set by the mental motivation of students, a use of their own mother language shall give them the psychologically important feeling to be "at home" and be satisfied with their elected scientific field, especially when they are just starting their scientific career. Yet, a proper command of multiple languages belongs to the key factors for having advantages and success in life. The same holds true in convincing strategically decision makers as regional and national politicians to invest (financially) in the development of B&B technologies by education and research.

Therefore, we have initiated a continuing project—to that of the French one given above—of multilingual education of students on a global scale and perspective which is shortly summarized in Table 1 and which has been started about 3 years ago. International colleagues have translated a general paper on bioindication and biomonitoring, which had been published in the English language before. The languages included are, for example, Arabic, Chinese, French, Latvian, Lithuanian, Farsi, Polish, Russian, and Spanish (for sure, inclusion of more languages, as for instance Hindi, Turk, and Portuguese are just under consideration at the moment). In addition to "mere" translation, the participating scientists will include special case studies on B&B technologies carried out in their own country. The translated papers have been finally published in national journals or books.

In the beginning, a Chinese Ph.D. student, working at the Research Center for Eco-Environmental Sciences of the Chinese Academy of Science, Beijing, translated the paper mentioned above (Markert et al. 2003) related to bioindication and biomonitoring technologies into Mandarin. A case study on pollutants in soils of Beijing has been added by the student. The paper has been published in *Acta Ecologica Sinica*, a peer-reviewed journal published by Elsevier at China (Markert et al. 2013a, Fig. 2a).

Also, an Iranian student from the Faculty of Environment and Energy, Islamic Azad University, Tehran, Iran had translated the general paper on B&B technologies including a related case study into the Persian language. This work has been published in the Iranian *Journal of Environmental Management and Planning* (Markert et al. 2013b, Fig. 2b).

Same holds true for the contribution of Lithuania (Fig. 2c) of which a young scientist, working for the Department of Environmental Protection at Vilnius Gediminas Technical University had been successful in the submission and publication of it in a peer-reviewed Lithuanian *Journal of Environmental Engineering and Landscape Management* (Markert et al. 2012a, 2012b, Fig. 2c).

As a final example, Fig. 2d represents the Polish article delivered by a young colleague, belonging to the Department of Agricultural Chemistry and Environmental Biogeochemistry at the Poznań University of Life Sciences, Poland. This article has been published in the Polish *Journal of Environmental Protection and Natural Resources* (Markert et al. 2012b).

Students (and all other individuals) interested in B&B technologies can find by this translated article innovative scientific motivation in their own mother language with a strong international relevance. They get mentally convinced and thus more easily convinced of these elegant and profitable "green" techniques, because we meet by the use of appropriate teaching and lecturing methods the rational and emotional intelligence of an audience and motivate them to move into our international working field (Markert et al. 2009).

B&B technologies are moving people, from continent to continent, from one organismic species to another, transdisciplinary from one scientific field to the other, from culture to culture or simply in having scientific interest on internationally connected ways and habits of thinking. Therefore, and as a conclusion, bioindication and biomonitoring methods will stay as Multi-Markered- Bioindication-Concept (MMBC) further on. Further information on MMBC is available in Markert et al. (2003).

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