Rev Environ Health 2011;26(1):31–38 © 2011 by Walter de Gruyter • Berlin • New York. DOI 10.1515/REVEH.2011.005

Hazardous waste in the Asian Pacific region

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Abstract

The production and disposal of hazardous waste remains a substantial problem in the Asian Pacific region. Remediation of waste disposal sites, including landfill sites, is attracting considerable research attention within the region. A recognition of the need for community engagement in this process is also growing. This article reviews the work presented in the Hazardous Waste sessions at the Pacific Basin Consortium for Environment and Health held in November 2009 in Perth.

Keywords: community engagement; landfill site; persistent organic pollutants; remediation; Stockholm Convention.

Introduction

Hazardous waste and its disposal remains a significant problem globally but is a particular problem in the Asian Pacific region. This issue has formed an important part of the agenda of the Pacific Basin Consortium for Environment and Health (PBC) since its inception, and sessions on hazardous waste have been included in PBC conferences. The conference held in Perth in November 2009 was no exception, and a lively session took place. This review will briefly summarize the issues presented in the session.

Black carbon

The role of black carbon (BC) in determining the fate and behaviour of organic pollutants was discussed by Thomas Bucheli from Agroscope Reckenholz Tänikon Research Station ART, Switzerland. Black carbon is a fraction of carbonaceous geosorbents produced by incomplete combustion processes (1). In essence, BC encompasses atmospheric recondensates like soots, carbon nanotubes, etc., or particulate residuals like chars and charcoal. Further geosorbents with analogue or similar sorption characteristics are coals or kerogens. Global estimates of total (airborne and residuals) BC are in the order of 50–200 Teragram/year [Tg/a], of which some 80% are estimated to be biomass derived (2). Fossil fuels contribute some 40%–67% of the airborne BC that amounts to 8–15 Gt/y (2, 3). Black carbon distributes globally via atmospheric transport and deposition, as well as surface runoff (2), resulting in residues that account for 6%–9% of total organic carbon in soils and sediments (1).

The generation of more accurate numbers and inventories of BC is, among other reasons, hampered by the use of different analytical techniques that quantify different fractions of the BC combustion continuum. For instance, the widely used chemo-thermal oxidation method at 375°C (4) is a much harsher isolation technique than wet chemical oxidation methods (5). Consequently, BC concentrations must be interpreted with care and should always be stated along with the method by which they were obtained. Black carbon plays an eminent role for the sequestration of carbon in soils (6), and is the second most important leading cause for global warming (7). Here, emphasis is on a third essential aspect of BC, namely, as a strong sorbent of organic pollutants.

Traditionally, the solid-water phase distribution of organic pollutants is rationalized with the following equation (8, 9):

$$K_d = \frac{c_s}{c_w} = f_{OC} \cdot K_{OC} \qquad [1]$$

where Kd is the solid-water distribution coefficient [Lwater/kgsolid], cw [mol/L] and cs [mol/kg] are the concentrations of the solute in the aqueous and solid phase, respectively, fOC is the fraction of organic carbon in the solid phase [gOC/kgsolid], and KOC [Lwater/kgOC] is the organic carbon – normalized partition constant. In laboratory sorption experiments, KOC of a given compound correlated with its octanol-water partition constant KOW [Loctanol/Lwater]:

$$\log K_{OC} = a \cdot \log K_{OW} + b \qquad [2]$$

More recently, however, observations of elevated sorption observations incompatible with this OMP model have frequently been reported (Figure 1). Further findings, such as non-linear sorption isotherms, multiphasic desorption kinetics, and variable biota to sediment accumulation factors (BSAFs) were also hard to reconcile with the OMP model. Probable reasons for the divergence between predicted and observed phase distribution are insufficient equilibration time and elevated solute concentrations in laboratory batch experiments.

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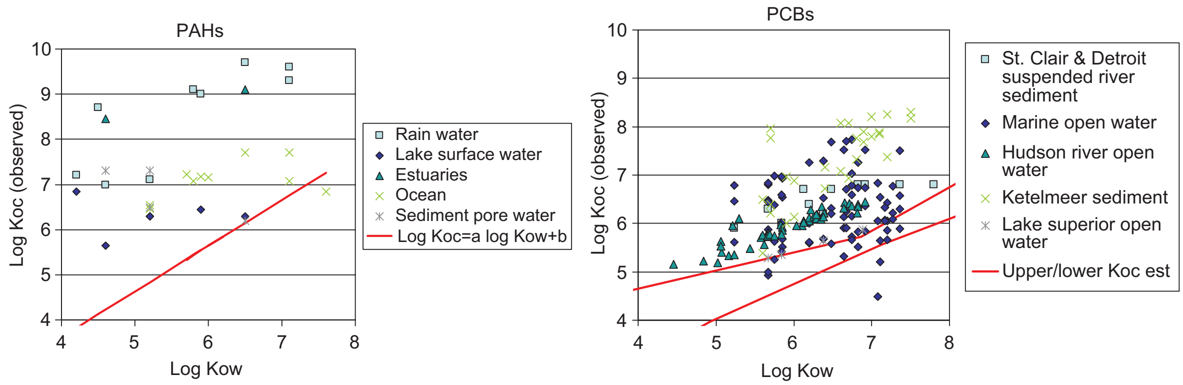

Figure 1 Organic carbon normalized in situ partition coefficients [log Koc (observed) for PAHs (left) and PCBs, elevated relative to organic matter OMP predictions (red lines)]. Data from references in (10) and (11). PAHs, polycyclic aromatic hydrocarbons; PCBs, polychlorinated biphenyls.

Altogether, this discrepancy led to the suggestion of a dual-mode sorption concept (12–15), in which OM was assumed to be composed of two domains, one (rubber-like) showing linear and non-competitive absorption, and one (glassy-like) displaying nonlinear, extensive, and competitive adsorption. In a critical review, Cornelissen et al. (1) compiled evidence that carbonaceous geosorbents such as BC are the interpretation of the "glassy domain" and that, consequently, Eq. [1] must be extended as follows:

$$K_d = \frac{c_s}{c_w} = f_{OC} \cdot K_{OC} + f_{BC} \cdot K_{BC} \cdot c_w^{n-1} \qquad [3]$$

in which fBC is the BC fraction present in the solid phase, KBC the Freundlich sorption coefficient to BC [(mol/kgBC)/(mol/Lw)n], and n the Freundlich nonlinearity coefficient. Figure 2 visualizes that the sorption coefficients of many organic pollutants to BC are indeed about one to three orders of magnitude higher than to OM.

In recent years, the application of the dual mode, BC inclusive, distribution model delivered predictions of solid-water distributions and dissolved exposures that were consistently closer to field observations than those based on the OMP model. Table 1 compiles a non-exhaustive list of examples.

Current soil and sediment quality criteria and bioremediation endpoints for organic compounds are based mainly on the OMP model. An extension of this model would allow better anticipation of the distribution of organic pollutants between particle-bound and dissolved (bioavailable) forms. Decision makers and legislators would thus be equipped with a more powerful tool for setting priorities regarding which contaminated sites are most efficiently and urgently remediated.

An interesting application that makes use of the strong affinity of many organic pollutants to BC is the amendment of activated carbon (AC) to contaminated sediments and soils. Adding a few percent of AC was shown to cause a drastic reduction of freely dissolved concentrations and desorbable fractions of pollutants. This remediation technique is currently generating considerable interest (22–26).

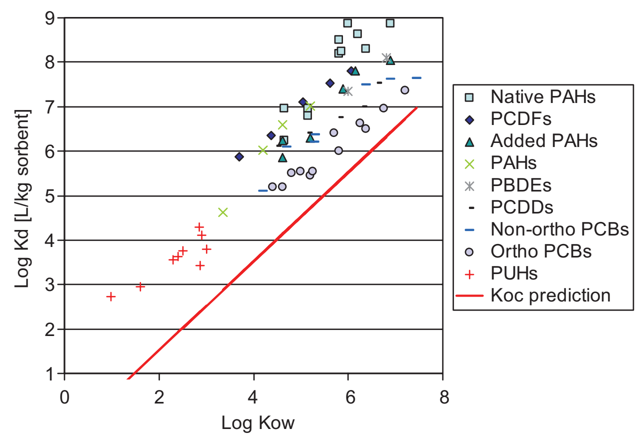

Figure 2 Observed adsorption coefficients to BC (log Kd) versus the octanol-water partition coefficient (log Kow) for a range of organic pollutants. The red line represents estimated OC sorption according to OMP. PAHs, polycyclic aromatic hydrocarbons; PBDEs, polybrominated diphenyl ethers; PCBs, polychlorinated biphenyls; PCDDs, polychlorinated dibenzo-*p*-dioxins; PCDFs, polychlorinated dibenzofurans; PUH, phenyl urea herbicides. Data from (16) and (17).

Heavy metals

Another area of regional concern is the presence of heavy metals in aquatic bodies. The major source of heavy metals is the improper discharge of various industrial wastewaters. Among the various heavy metals, the potential sources of chromium include leather tanning, paints, dyes, photographic materials, steel alloy, cement industries, mining, and nuclear power plant coolant water. Selvaraj Rengaraj from the University of Kuopio, Finland discussed the use of nanotechnology to solve an intractable environmental problem caused by Cr(VI) contamination, particularly in the leather industry.

Chromium occurs in two common oxidation states in nature, Cr(III) and Cr(VI). The behavior of chromium species strongly depends on its oxidation state. Cr(VI) is mobile and highly toxic, whereas Cr(III) is mostly immobile and environment-

Table 1 Examples of a successful application of the dual mode, BC inclusive, distribution model.

Compound(s)	Location	Observation/Key finding	References
Pyrene	Humber estuary open water column	Better prediction of pyrene K_ds by a BC-inclusive distribution model	(11)
PCDD/Fs	Grenland fjords sediment	Geographical distribution of PCDD/F in sediment is better accounted for by soot carbon than by TOC, as indicated by consistently higher linear regression coefficients	(18)
Pyrene, phenanthrene	Lab studies with New England sediments	Better prediction of *Nereis virens* lipid-normalized tissue concentrations by a BC-inclusive bioaccumulation model	(19)
PCDD/Fs	Grendland fjords sediments	Better prediction of PCDD/Fs K_ds by a BC-inclusive distribution model	(20)
PAHs	Stockholm sediments	Better prediction of PAH K_ds by a BC-inclusive multi-media fate model	(21)

friendly. Cr(III) plays an role in plant and animal metabolism, whereas Cr(VI) is directly toxic to man, animals, and plants. The methods commonly employed for the removal of Cr(VI) are chemical precipitation, reverse osmosis, ion exchange, foam flotation, electrolysis, photocatalytic reduction, and adsorption, which are all energy- and resource-intensive. A new photocatalytic process that is quite energy efficient and economical was discussed. In essence, a series of titanium dioxide (TiO_2) doped with neodymium (Nd) was prepared by the sol-gel method and used for the photocatalytic reduction of Cr(VI) under UV illumination, to determine its photocatalytic properties. A series of Nd^{3+}-TiO_2 catalysts prepared with different Nd^{3+} dosages was characterized by XRD, Raman spectroscopy, SEM, EDX, TEM, EDS, and XPS spectroscopy. Formic acid was used in these experiments as a hole scavenger to enhance the photocatalytic reduction action.

The experiments demonstrated that Cr(VI) was effectively reduced in aqueous Nd^{3+}-TiO_2 suspension by more than 95% within 60 min, whereas the pH of the solution increased from 3.1 to 3.35 due to the consumption of formic acid. The experimental results indicate that the presence of Nd^{3+} in TiO_2 catalysts substantially enhances the photocatalytic reaction of chromium(VI) reduction. The optimal dosage of 1–3 wt% Nd^{3+} in TiO_2 achieved the fastest reaction of Cr(VI) reduction under the experimental conditions. The neodymium ions deposited on the TiO_2 surface behave as sites at which electrons accumulate. The improved separation of electrons and holes on the modified TiO_2 surface allows more efficient channelling of the charge carriers into useful reduction and oxidation reactions rather than recombination reactions. The presence of sacrificial electron donors such as formic acid enhances the photocatalytic reduction of Cr(VI). The Cr(VI) adsorbed on the surface of the TiO_2 particles was observed to be almost completely photoreduced to Cr(III). The data demonstrate the potential of heterogeneous nano-sized photocatalysis to decontaminate wastewaters containing heavy metal.

Waste minimization through education and training

Central to the issue of reducing hazardous waste is the finding of ways to minimize the production of waste, and ultimately to eliminate it. As discussed by Margaret-Ann Armour from the University of Alberta, Canada, there is a growing awakening that instead of focusing our attention on developing and practicing waste disposal strategies, we have to develop ways and means to minimize the waste generation itself. In this context, it has also become important to bring out attitudinal changes and awareness about strategies and methodologies that help to minimize or eliminate the hazardous waste during the education of future managers. Strategies for the minimization or elimination of waste can be taught in the classrooms of schools and post-secondary institutions; in teaching laboratories, hands-on experience of disposal procedures can be provided. Several of the methods for the disposal of small quantities of hazardous chemicals that have been tested and developed in laboratories can be incorporated into laboratory experiments. In this way, students are made aware of responsible waste disposal.

Pilot projects were carried out with faculty and students at a university in Thailand with encouraging results. Within the teaching laboratory, a variety of strategies can be practiced to reduce or eliminate waste chemicals to raise student awareness of the need for good management practices that can subsequently be applied in the workplace, e.g., acid-base neutralization; conversion of toxic organic chemicals to non-hazardous ones; conversion of potentially explosive chemicals to less hazardous materials; precipitation of heavy metals as insoluble salts; recycling and exchange; spill management.

As an example of conversion of a toxic organic chemical, the case of ethidium bromide may be considered; this substance is commonly used in molecular biology laboratories and is stated to be mutagenic. Due to the adverse impact on the health of persons coming into contact with this chemical, discarding it down the drain is prohibited and it must be carefully destroyed. When 34 g of this substance is taken in 100 mL of water and mixed with 300 mL of household bleach and stirred for 2 h, the ethidium bromide converts into harmless compounds, 2-carboxybenzophenone and phenylphenanthridine.

As a next example, picric acid may be considered; this substance is potentially explosive, and therefore its residues or unused portions must be carefully destroyed. The best way to deal with such a chemical substance is to reduce the nitro groups by a reaction with tin (Sn) and subsequently to oxidize the amine groups with acidic potassium permanganate. Similarly, Cr salts may be precipitated with sodium thiosulfate solution; the copper salts in solutions could be precipitated as insoluble copper silicate. Similarly silver-containing solutions can be used to precipitate silver chloride.

Further, the students should also be well trained to handle spill mix and to adopt other good practices in the laboratory. On the work site, these methods can be used to dispose of waste and surplus chemicals from industrial quality control and testing laboratories, from greenhouses, from hospital pharmacies and doctors' offices, from research laboratories, and from school and university teaching laboratories. Frequently the principles of the methods can be used to formulate ways of managing industrial waste streams to greatly reduce or eliminate environmental pollution.

Soil remediation

The health of the soil is an area of continuing concern within the Asian Pacific region. As discussed by Rajendra Prasad from the Indian Network of Soil Contamination Research, a spurt in soil remediation technologies has occurred throughout the world during past few decades in response to the growing concern about the deteriorating soil environment. The analysis of patent databases has of late come to be recognized as a potent means to gain insight into the trends of development in any given technology field. A recent study was undertaken investigating the review of soil remediation technologies through the techniques of patent analysis and mapping. The visualization of patent data through these techniques has emerged as a powerful tool to review different aspects of a technology area that are receiving the attention of researchers in different parts of the world. It has been highlighted that 'competitive intelligence' through such patent analysis is now being routinely employed by large multi-national groups to plan their future research efforts strategically, to evaluate the strength of their own patent portfolio relative to competitors, and to identify potential opportunities for licensing as well as strategic partnerships throughout the world.

Matheo Patent Software was employed in this study, in which as many as 1178 patent records for past 20 years were returned from the European Patent Office worldwide database through appropriate keyword searches. This data set was assumed to be fairly comprehensive on a global basis, as the database covers the patent data from more than 90 countries; therefore no further data was sought from other sources. The data set was also assumed to be representative of all known soil remediation technologies covering the period of the past 30 years, as much of the world's focus research attention took place in this period.

Bibliographic analysis of the patent data set as obtained above, brought forward that there were as many as 1012 inventors and 528 applicants spread all over the world in this technological area. The names of Vinegar, Harold J. and Stegemeier, George Leo come up as most prolific inventors when the data set is sorted on the inventors' names. Vinegar, Harold J. appeared in as many as 94 records as an inventor with the applicant for these patents being Shell Oil Company in the United States (US), Shell Oil Canada, and Shell Research Centre in the Netherlands. The name of the inventor, Stegemeier, George Leo is the next most prolific inventor in this field, the database coming up with his name for 75 patents.

The geographical distribution of the patents held by the above inventors is quite widespread; these have been secured in countries such as Austria, Denmark, Czechoslovakia, South Korea, Hungary, US, Canada, Poland, Taiwan, European Union, etc. Most of the patents with above inventors' names deal with thermal treatment for soil remediation suitable for removal of volatile contaminants and mercury. Looking more closely through the citation analysis, we concluded that some of the patents obtained by these inventors represented a major landmark in the technology development in this field, as these have been cited more than 100 times subsequently.

Compost decontamination of soil contaminated with chlorinated toxic substances appeared to be next most important technology held by the inventor Gray, Neil C. C. of Zeneca Corporation with as many as 66 patents. Different patents deal with different toxicants, such as PCP, DDT, TNT, HMX, RDX, PCB, methoxychlor, etc. The patents have been taken out in the US, Canada, Hungary, South Korea, Czechoslovakia, Spain, and the European Union.

Sorting on patent applicants, the major patent holders in soil remediation technologies were immediately apparent. However, to review the status of technology, the data set was sorted on IPC codes; the current patent grant process worldwide assigns a classification as per universally granted code to the patent and therefore represents the technological aspect as precisely as possible.

Looking at the number of patents and their families against these IPC codes revealed that almost equal attention seems to have been paid to various technological approaches in this domain. Thus, whereas 433 patents are related to decontamination through chemical treatment represented by code B09C1/08, 371 patents are represented by code B09C1/10 for decontamination through biological methods. Similarly, technologies using thermal decomposition of contaminants number 358 (represented by code B09C1/06) and those based on extraction by way of washing and leaching amount to 265 (represented by code B09B3/02).

The uptake by plants of toxic contaminants present in the soil constitutes a serious problem for public health. Despite their ban for several years now, residues of the organochlorine pesticides (OCP) present in some soils continue to pose this danger. Hilber Isabel from the Research Institute of Organic Agriculture, Switzerland presented data from a study designed to demonstrate a possible reduction in uptake of OCP (dieldrin residues in this case) from soil by plants such as cucumber through soil amendment with powdered activated charcoal (AC). Given that total OCP concentrations are poor indicators of OCP uptake by plants, the research was also aimed at assessing the phytoavailability of bound OCP residue through an extraction process by means of Tenax® beads that showed promising potential in previous studies carried out by the authors. Tenax® is a porous polymer and is used as an infinite sink for the desorption of organic pollutants from soils and sediments.

Two pot experiments in 2006 and 2007 were carried out in a soil that was contaminated with weathered dieldrin (70 µg kg) in which cucumber plants (*Cucumis sativus L.*) were grown. Five-liter pots were used in all experiments and each AC treatment (0, 200, 400, and 800 mgAC/kg soil) was carried out in six replicates. Sixteen-days-old cucumber plants, one in each pot, were planted after uniform process of irrigation of each pot. Cucumbers were harvested once they were ripe, in 2006 after 13 weeks and in 2007 after 11 weeks, and analysis of dieldrin in cucumber fruits was carried out as per procedures reported in literature. Consecutive Tenax® extractions were conducted with moist, untreated (0 mgAC/kg), and treated soil (800 mgAC/kg) from the 2007 experiment after the cucumbers had been harvested. Single (6 h) Tenax® extractions were carried out with pot soils from 2006 before cucumber planting, and after 13 weeks in planted and unplanted AC-amended soil. Tenax® extractions were analyzed, revealing that dieldrin concentrations in cucumbers ranged from 2 ng/g fw in AC-treated soils to about 12 ng/g fw in a control soil, and concentrations were equal or lower in AC-amended soils than in their controls. Although in 2006, the AC treatments significantly reduced dieldrin concentrations by almost a factor of three, in contrast, AC had no effect at all on dieldrin concentrations in 2007. Activated charcoal comparisons by the Bonferroni test of the pooled data revealed significant reductions of dieldrin between 400 and 800 mgAC/kg amendments compared with the control soil. The data illustrate that AC amendment is – under certain conditions – capable of changing a situation in which tolerance values are surpassed into one that is satisfactory.

Dieldrin Tenax® extractions from the control soil and the soil amended with 800 mgAC/kg were modelled incorporating three different desorption kinetics/fractions (Frap, Fslow and Fv.slow) as a model described by Cornelissen et al. (1). The cumulative extraction is depicted in Figure 1 for the control and the AC-amended soil, respectively.

According to the model, the Frap fraction desorbed within a short time of about an hour (Figure 1). The Fslow fraction was depleted after about 100–200 h. The results from the control soil indicate that both the fast and the slow dieldrin fraction probably had enough time to redistribute with AC in the AC-amended soil over the contact time of 11 weeks, although pot soils were not water-saturated. Note that some 40%–50% of the total ASE extractable dieldrin amount (70 ng/g) was not available to Tenax® desorption within the investigated time period of 1000 h. Less dieldrin desorbed from the AC-amended than from the control soil. If AC amendment is an effective measure, Frap or Fslow should decrease whereas Fv.slow should increase. In fact, Figure 2A and B show an increased Fv.slow in the AC-amended soil compared with the control soil. Fv.slow was about 8.6% higher in the AC-amended soil compared with the unamended soil. In contrast, Fslow was lower in the AC-amended soil than in the control soil. Hence, AC amendment provoked a shift from dieldrin formerly bound in Fslow to Fv.slow.

Thus, AC amendment of 800 mgAC/kg was found to reduce the dieldrin fw concencetrations by 0%–66% compared with the untreated soil. At the highest AC amendment no significant change occurred in 6 h Tenax® extractable dieldrin with time, indicating that any mobilized dieldrin was effectively bound by the AC, which is important in practical applications of such amendments. This result is also in line with the observed increase in the very slow Desorption fraction in the AC-amended soil. The researchers also concluded, that Tenax® extractions are probably not an ideal measure to reflect long-term uptake by plants, but Tenax® extractions mirrored the AC effect. This method could therefore be used as a quality control measure for in situ remediation strategies such as AC amendment. These areas of research deserve further investigations.

Along similar lines, Younas Asma from the Department of Environmental Sciences, University of Peshawar, Pakistan, presented results of laboratory tests for the remediation of a DDT-contaminated site in Pakistan through treatment of activated charcoal (AC). The site for remediation was around an erstwhile DDT production plant where the concentrations of DDT in soil within a distance of a few 100 m around the factory are up to 7 µg/g DDT in dry soil, and as high as >1800 µg/g close by. The investigators used AC amendment to bind and immobilize the DDT and its metabolites in the soil and measured AC sorption coefficients in DDT-contaminated samples from the affected site. Selected plots with different contamination levels were chosen for this pilot study. Two sets of soil samples were prepared with 5% PAC (powdered activated charcoal) and 5% GAC (granulated activated charcoal) along with a control sample. Availability of DDT concentrations (in terms of p,p′-DDT and o,p′-DDT) after adsorption on Tenax® beads (porous polymer) was determined. The authors concluded from the experiments conducted that AC exhibits strong sorption of DDT, and reduction of the desorbing fraction of p,p′- and o,p′-DDT by about 36% and 60%, respectively, in the GAC dry amended soil was observed in laboratory conditions. This technique promises a cheap, effective, and feasible way to remediate other organically contaminated hotspots in South Asia.

Persistent organic pollutants

Despite being banned under the Stockholm Convention, exposure to persistent organic pollutants (POPs) continues in many parts of the Asian Pacific region. Mahmood Khwaja from the Sustainable Development Policy Institute, Islamabad, Pakistan reported the results of a survey, conducted in Pakistan during 2006, of sources of 12 black-listed POPs that broadly cover the dioxins, such as polychlorinated dibenzo-p-dioxins (PCDDs), furans (F), and polychlorinated dibenzofurans (PCDFs), as well as polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB). The sites surveyed were Peshawar (Brick Kiln, Canal Road, Ahmad Khel) and Lady Reading (LRD) Hospital; Quetta (Children Hospital, Quary Road); Islamabad [Pakistan Institute for Medical Sciences (PIMS)] and [Al-Shifa International Hospital].

Three distinct pathways for the formation of PCDDs/Fs have so far been proposed, namely, pyrosynthesis, low temperature pyrosynthesis of macromolecular carbon and organic or inorganic chlorine present in the fly ash matrix, and formation from organic precursors in which fly ash has an important role as a catalyst. All these mechanisms occur during incineration, and hence all target sites for this study are around incinerators. Samples weighing 400–500 g each were taken from the bottom ash of incinerators and from bottom ash plus soot from the brick kiln 10–14 h after the incinerator furnaces were turned off. The samples were airlifted for analysis at Ecochem Laboratories, Czech Republic for PCDDs/Fs and PCBs on Agilent 6890N/Finnigan MAT 95XP and for OCPs and their metabolites by GC-ECD/GC-MS according to EN ISO 6468 and DIN 51527.

Altogether as many as 17 dioxins/furans were detected in all ash samples above the LoD (level of detection), except one. Four PCDDs and two PCDFs (among the normally measured 17 cogeners) were not detected. Dioxins in ash samples from the four medical waste incinerators studied were observed at levels ranging from 50.57–2290.30 pg 1-TEQ/g.d.m. Dioxin-like PCBs were observed in levels 0.12 up to 146.45 pg 1-TEQ/g.d.m. Some fly ash from municipal waste incinerators in Europe and Turkey had lower levels of dioxins than in ash samples from medical waste incinerators in Pakistan. Concentrations of 0.12 pg 1-TEQ/g.d.m. found in samples from PIMS (Islamabad) and Quetta Hospital are lower than those recorded for Germany or Taiwan.

The health effects of POPs are well recognized. POPs enter the food chain in animal products such as meat, fish, and milk and are known to accumulate in the developing fetus. Children are more prone than adults to the harmful effects of POPs. The Stockholm Convention on POPs requires that each party shall, at a minimum, take necessary measures to reduce the total releases from anthropogenic sources of the chemicals (PCDDs, PCDFs, HCB, and PCBs) listed in Annex C (of the Convention), with the goal of their continuing minimization and, where feasible, ultimate elimination. One hundred and fifty-two countries are signatories to the Stockholm Convention, but Pakistan is not one of these. In view of high levels of POPs detected on various sites, an early ratification of the Stockholm Convention on POPs by Pakistan would be advisable, as well as the launch of a comprehensive monitoring program of POPs and sound strategy to deal with this growing threat to public health.

Community engagement in waste management

Solid waste disposal is an issue throughout the Asian Pacific region. The appropriate choice of use for landfill sites post-closure can avoid or minimize environmental and health problems caused by methane, waste subsidence, and land contamination. Marie Lourdes from Edith Cowen University in Perth presented this issue using a local example. Tamala Park Landfill, a class II landfill located in Perth, is expected to close around 2020, and the decision concerning its post-closure land use has not yet been made. Popular post-closure uses for landfills include sports grounds, industrial developments, residential developments, and the creation of wildlife habitats. The choice for post-closure uses of landfills has a direct positive or negative impact on the community living around the landfill. It is therefore important that community input is obtained in the process of decision making relating to landfill closure. Research was conducted to identify options for the post-closure land use of Tamala Park using community input and to explore options for community involvement inpost-closure landfill management issues.

A postal questionnaire was sent to a sample of 836 residents randomly selected from suburbs adjacent to the Tamala Park landfill site requesting views and awareness on landfill issues, preferences for post-closure land use, and willingness and availability to volunteer in a community participation process. Preliminary data from 160 respondents, including 60% females in the age range of 35 to over 65 years, have been analyzed. The majority of respondents (98%) are aware of the landfill site and have recently received information about it (>72%). However, very few respondents have been consulted (5%) about the landfill or are aware of the projected closure of the landfill (29%). Although few respondents (16%) are concerned about the landfill issues or want to be involved in its decision making (20%), issues such as fire, flies, odor, dust, physical appearance, and property value were considered important issues especially by those living closer to the landfill site. The majority of respondents (56%–85%) chose wildlife restoration, open space, golf course, sports ground, and plantation forestry as appropriate post-closure land use for Tamala Park, whereas the options of agriculture, commercial development, industrial development, ongoing waste management, and housing were considered as inappropriate by most respondents (52%–91%).

Continuing the theme of community engagement in environmental issues, Sri Irianti from the School of Engineering, Griffiths University, Queensland reviewed the status of health care waste management (HCWM) practices in Indonesia, which is reported to have 1292 hospitals and 7609 health centers in 33 provinces, nearly half of which are in the private sector, and the remainder in the government sector, including local governments. The importance of safe management of healthcare waste cannot be over emphasized because unsafe medical waste poses significant public health hazards through infectious, radioactive, toxic, genotoxic, and flammable wastes. The objective of the study was, therefore, to elicit relevant information on current HCWM from key stakeholders, particularly with regard to the roles and responsibilities of key personnel within the HCWM hierarchy, their capability to deal with issues, available waste treatment technologies, and their awareness of regulations and policies.

The study involved in-depth interviews with relevant stakeholders in as many as 10 hospital and 10 public healthcare managers in five provinces and the officials of the Indonesian Hospital Association, Ministry of Health, State Ministry of Environment, National Nuclear Energy Agency, along with relevant desk based research. The data collected revealed a general lack of standard operating procedures on HCWM and infection control and most centers also did not have personal protective equipment. In general, the hospitals studied lacked any capacity building, training, and awareness programmes. Further, the majority of healthcare facilities was not found to be familiar with the HCW segregation system; only 55.30% hospitals segregate their wastes into two or more categories. The majority of waste treatment was found to be through incineration, but a general lack of appropriate waste treatment facilities for liquid wastes was noted.

The above situation persists despite a score of regulations and Acts prevailing in Indonesia, including the Conservation and Management of the Environment Act No. 32/2009; the Solid Waste Management Act No. 18/2008; Government Regulation No. 85/1999 (Hazardous Waste Management); Government Regulation No. 27/1999 (Radioactive Waste Management); Health Ministerial Decree No. 1204/2004; and Environment Ministerial Decree No. 58/1995. Thus a foolproof mechanism is needed for implementing the CWM policies and plans with adequate budgetary support from the government.

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