Pathway-oriented assessment of waste deposit properties in Haryana, India

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Introduction

In India there are many places where different kinds of waste are deposited by municipal committees or private organizations. The dumping sites are mostly not properly guarded and well maintained. They offer easy accessibility for animals such as birds, cows and dogs which may contribute to the dispersion in and around dumping sites. Since usually the waste appears to be not well seperated, a mixture of domestic, commercial and industrial waste can be frequently expected. Hence, apart from organic garbage, the waste might contain potentially toxic substances (Rawat et al. 2008, Williams 2005).

Many waste pickers are present at the sites who try to separate the waste body in order to collect valuable materials for recycle purposes. These people, adults as well as adolescents, are continuously exposed to the material and its pollutants. Moreover, people living in catchment areas are exposed to the contamination in different ways. Leachate runoff during rainy seasons can contaminate the surrounding low-lying areas used, for instance, as cropland. Subsequently, plants that are grown in the adjacent areas and that are consumed afterwards by people take up contaminants. Simultaneously, mobile contaminants percolate downward below the waste deposit reaching the groundwater. In vicinity of the waste sites a number of private wells is positioned leading to the consumption of the groundwater previously influenced by the contaminants derived from the waste deposits (Meuser 2010).

In the following text the distinct exposure scenarios are introduced and calculated related to the human contaminant intake for three dumping sites in the Federal State of Haryana.

Study sites and procedure

The three sites located in Haryana are 3-4 years (Karnal), 8-10 years (Jind) and 35-40 years (Rohtak) of age, respectively. The waste was sampled to the depths of 0-1 m and 1-2 m. At the three locations, three blocks of app. 1,000 m^2 each were taken. Using window augers in these blocks 15 randomly selected points were sampled and afterwards unified to a mixed sample. In this way six samples were collected from each site (two depths, three blocks). Internationally accepted methods were used for laboratory analysis. In more detail, investigation sites and methods have been reported in Meuser et al. 2011.

Waste characteristics

The landfills mainly contained fine earth (62-66 %) consisting of mineral particles, organic residues and ashes as well as constructions debris (20-25 %). As shown in Tab. 1, the percentage of recyclable components was reduced to small amounts due to the activities of the waste pickers.

	Wood	Plastic	Glass	Metal	Textiles/ Leather
Rohtak	5.3	5.7	1.2	0.2	2.3
Jind	3.0	3.4	1.1	0.4	0.9
Karnal	2.4	5.0	0.8	0.2	4.3

Tab. 1: Percentage of recyclable components (%)

Total organic carbon (TOC) ranged from 3.8 to 5.4 %. The relatively low organic matter content might be a result of animal consumption, since birds and cows are constantly present. With reference to the C/N (carbon/nitrogen) ratio of 9-13 an intensive and (an)aerobic degradation appeared to occur. The waste material indicated an accelerated nutrient content; for instance, the plant available phosphorus concentration ranged between 8.4 and 38.3 mg $100g^{-1}$. In soils of urban environment values exceeding 10 mg $100g^{-1}$ are assessed as high, values exceeding 16 mg $100g^{-1}$ as very high (Meuser 2010). The pH value of app. 7.6 might be explainable by the high percentage of calcium enriched construction rubble.

Exposure scenario waste – human (direct contact)

The direct contact is associated to three possibilities:

- Oral ingestion (hand-to-mouth behavior, consumption of contaminated food)
- Inhalative ingestion (inhalation of dust particles in dry seasons)
- Dermal uptake (direct contact to unclothed body parts).

In Fig. 1 the direct contact is illustrated. During waste collection a woman was sitting at the dumping site touching the waste and inhaling the gases produced in the waste deposit.

Fig. 1: Waste picker in Rohtak

Using the example lead (Pb) the concentration reached or exceeded the quality standard for direct contact in Germany (200 mg/kg) (BBodSchV 1999) (Fig. 2). The German thresholds are used, because in India there are no quality standards published. The trigger values, however, are calculated for an exposure of 1.5 h per day and 200 days per year which is not realistic in relation to the behavior of waste pickers. In the case of a more realistic daily stay of 8 hours and, for instance, 300 days per year the trigger value has to be reduced to 25 mg kg^{-1}. Consequently, the exceedances would be considerably higher.

Exposure scenario waste – food chain

Vegetable plots are in straight proximity to waste sites (Fig. 3). Lateral contaminant percolation is possible to occur (see arrows) causing additional problems for the people living in the catchment area.

Fig. 3: Low-lying vegetable plots influenced by runoff in Karnal

As seen in Fig. 4 the plant available heavy metal concentration indicated high percentages for different elements. Thus, plants are able to take up mobile contaminants such as cadmium (Cd), copper (Cu) and lead (Pb). In this way the metals are possible to enter the food chain.

Exposure scenario waste – drinking-water - human

Fig. 5 reveals the results of the well water which was collected nearby the dumping sites and is used for drinking purposes of the people living in vicinity of the waste deposits. Exemplarily, the cadmium (Cd) and lead (Pb) concentrations are shown. The WHO quality standards of 0.01 mg L^{-1} (Pb) and 0.03 mg L^{-1} (Cd) for drinking-water (WHO 2011) were exceeded to a great extent.

Additional sources of contamination

People living in the catchment area of the dumping sites are exposed to additional contaminants. In Haryana, for example, the concentration of particulate matter (PM < 2.5 µ) is very high compared with other Federal States in India. PM 2.5 adsorbs high metal concentrations (WHO 2015). The inhalation of PM 2.5 additionally might contribute to the contaminant ingestion. Locally, gas volatilization at the dumping sites (e.g. CH_4, H_2S) are further sources of contamination for the waste pickers (Meuser 2010).

Conclusions

Rag-pickers are exposed to potentially contaminated landfills to a great extent. Based on a daily stay of 8 hours and 300 days per year the exposure would exceed the thresholds for different heavy metals published in e.g. Germany referring the direct contact (oral, inhalative, dermal). The exceedance for Cd, for instance, amounted to 8- to 32-fold.

In the case of consumption of food growing in vicinity to the waste deposits and water extracted downstream the deposits by private wells the metal uptake considerably increased. For Cd the exceedance based on the WHO standard was 0.6- to 1.7-fold (food consumption) and 7- to 8-fold (drinking-water), respectively.

Apart from the direct waste impact diffuse air pollution and gas development of the landfill sites may additionally contribute to the danger to human health.

From the health risk point of view the waste pickers' everyday life is not acceptable. The main reason, however, might be the economic necessity of the waste pickers to earn sufficient income. Nevertheless, protective measures such as wearing of gloves and mask as well as at least the exclusion of children inserted by the local governments could be helpful to reduce the human health risk. Unfortunately, in this regard initiatives are not recognizable up to now.

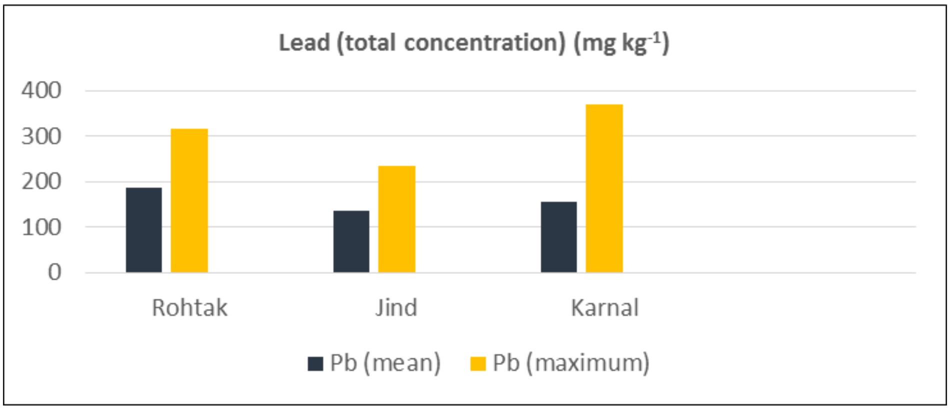

Fig. 2: Pb concentration of the waste material

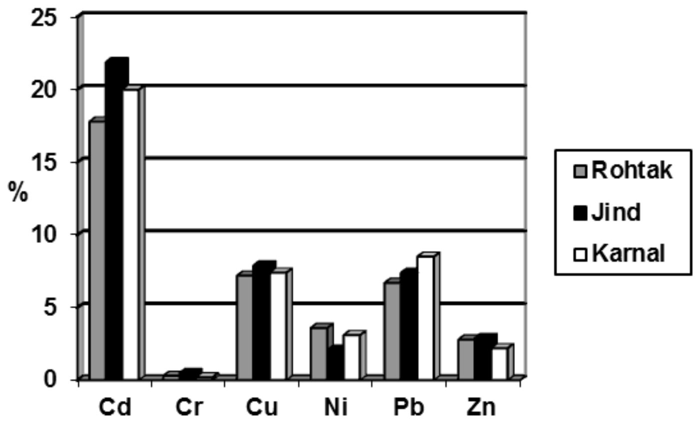

Fig. 4: Percentage of plant available concentration (DTPA extraktion) to total concentration (%)

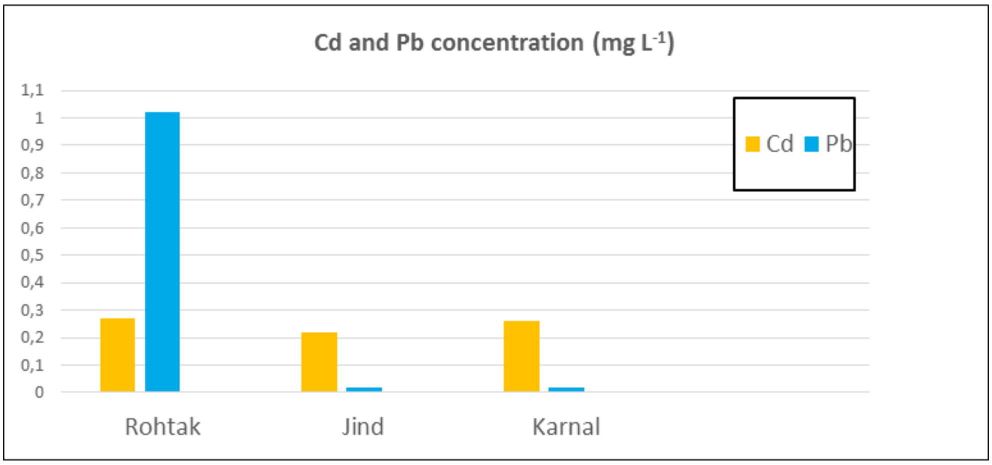

Fig. 5: Cd and Pb concentration of well water in proximity to the waste deposits

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