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Selection of Bottom Liner for Land Disposal of Industrial Waste Containing Lead-Case Study: Tabriz Petrochemical Complex

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Abstract: Industrial wastes generated at Tabriz Petrochemical Complex (TPC) were shown to contain significant concentration of lead. Environmentally sound landfilling of these waste streams was studied in terms of potential risk of associated groundwater contamination. The waste was to be disposed of in a landfill overlying an aquifer of fine sand texture and a water table depth of about 9 m. A modeling approach was employed for estimating the concentration of lead in groundwater downstream of the landfill site. The Industrial Waste Evaluation Model (IWEM) developed by US Environmental Protection Agency was used which estimates the receptor dose of lead, calculates the associated human health risk and recommends protective measures (i.e., liner type). Accordingly the appropriate liner being of composite type was selected as the required protective measure to minimize the transport of lead to the underlying aquifer which is a major source of drinking water for the downstream residential communities.

Key words: Industrial waste, lead, human health risk, landfill, IWEM

INTRODUCTION

As a developing country having rich resources of oil and gas, Iran has experienced a significant industrial growth mainly in the field of oil and gas industries. Petrochemical complexes play a major role in the overall economy of the country and therefore have shown a considerable growth over the last decades.

Petrochemical industries are of high potential for environmental pollution in terms of different emissions to the atmosphere, soil and water resources. The main source of soil and water resources (especially local aquifers) contamination originates from the disposal of wastes generated throughout the industrial processes. These wastes contain various amounts of contaminants including heavy metals, which can pose significant risks to public health through potentially contaminated groundwater consumption.

Tabriz Petrochemical Complex (TPC) has allocated a site for landfilling of the industrial waste which includes substantial amounts of hazardous components, realizing the crucial importance of environmentally sound waste disposal.

As a vital part of industrial and hazardous waste management system, the landfill lining material and configuration was to be decided so as to avoid local groundwater contamination to heavy metals (Woodside, 1999; Carson and Mumford, 2002; Lagrega *et al*., 2001). Among a number of heavy metals present in different waste streams of TPC, lead was found to be of the highest concentration and probably posing the largest threat to the local groundwater resources which partly serve as drinking water supply.

Heavy metals in the available forms (i.e., exchangeable or adsorbed to the surface of clay, organic matters or oxides with weak bonding strength, etc.) are easily moved and dispersed into the ecosystem. Metals bound with organic ligands or held within a crystal lattice, however, are not easily separated and moved (Fletcher, 1981; Thomson and Wood, 1982).

Health effects associated with exposure to inorganic lead and compounds include, but are not limited to, neurotoxicity, developmental delays, hypertension, impaired hearing acuity, impaired hemoglobin synthesis and male reproductive impairment. Importantly, many of health effects associated with lead may occur without overt signs of toxicity. Lead has particularly significant effects in children, well before the usual term of chronic exposure can take place. Children under 6 years of age have a high risk of exposure because of their more frequent hand-to-mouth behavior (USEPA, 1984, 1986, 1989).

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Accordingly the lining system was to be determined based on the lowest Human Health Risk (HHR) associated with the release, fate and transport of lead through the vadose zone and consequently to the aquifer underlying the TPC industrial waste disposal site.

MATERIALS AND METHODS

Site characteristics: TPC with an area of 391 ha is located near Tabriz refinery at the southwest of the city of Tabriz at an elevation of 1362 m above sea level. This petrochemical complex dominantly produces plastics such as polyethylene and polystyrenes.

From a geological perspective, TPC is located over Tabriz-Azarshahr aquifer with an area of 1541 km^2. The aquifer consists of marl, silty marl and gypsum sediments based on which the underlying soil is characterized as being fine textured.

The depth of groundwater table in the aquifer varies between 5 m to more than 20 m bellow natural ground surface as shown in Fig. 1. The average depth of groundwater table underlying the TPC is about 10 m.

It is worth noting that this aquifer is considered as the predominant drinking water supply source for the city of Tabriz. This makes the aquifer crucially important necessitating the prevention of contaminations through possible leakage of toxic contaminants such as lead. Water table depth and transmissirity along other characteristic are shown in Table 1.

Waste characteristics: Industrial waste generated at different units of TPC was characterized in terms of Toxicity Characteristic Leaching Procedure (TCLP) concentration for lead. The wastes containing lead are shown in Table 2 along with the related TCLP concentrations. It was assumed that a combination of the wastes containing lead would be disposed of in land.

Model description: The Industrial Waste Evaluation Model (IWEM) software helps determine the most appropriate Waste Management Unit (WMU) design to minimize or avoid adverse groundwater impacts by evaluating one or more types of liners, the hydrogeologic conditions of the site and the toxicity and expected leachate concentrations of the anticipated waste constituents. The software can help compare the groundwater protection afforded by various liner systems with the anticipated waste leachate concentrations, so that the minimum recommended liner system that will be protective of human health and groundwater resources can be determined (USEPA, 2002a, b).

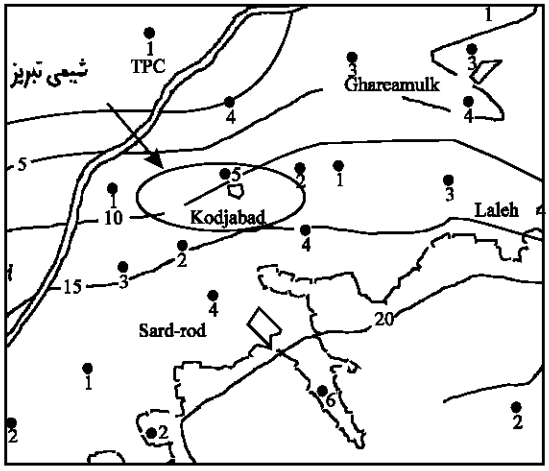

Fig. 1: Variation of groundwater depth around TPC

Table 1: General characteristics of Tabriz-Azarshahr aquifer

Aquifer thickness (m)	Maximum	300
	Minimum	120
Water table depth (m)	Maximum	97
	Minimum	0.5
	Average	13
Transmissivity (m^2 day^{-1})	Maximum	1022
	Minimum	31
Groundwater consumption (million m^3 year^{-1})	Drinking	87 (26% of total)
	Industrial	13 (4% of total)
	Agricultural	240 (70% of total)

Table 2: Results of lead TCLP tests for wastes generated at TPC

Waste types	Generation rate (ton year^{-1})	TCLP concentration (ppm)
Incinerator ash	525	199
Dry sludge from wastewater treatment plant	44	76
Used activated carbon	44	67
Used diatomite from compounding unit	44	78

The IWEM tool compares the expected leachate concentration for each waste constituent that is entered by the user with the Leachate Concentration Threshold Value (LCTV) or exposure concentration calculated by a groundwater fate and transport model for three standard liner types. The IWEM software compiles the results for all constituents expected in the leachate and then reports the minimum liner scenario that is protective for all constituents.

The liner types include no liner (*in situ* soil underlying the Waste Management Unit (WMU), single clay liner and composite liner.

The computational engine of IWEM software is the EPACMTP model which is integrated with Monte Carlo processor that performs the ground-water fate and transport simulations for Tier 2 evaluations. EPACMTP is

Table 3: Landfill dimensions required for industrial waste disposal at TPC

Waste type	Volume (m^3)	Area (m^2)	Total depth (m)	Depth bellow ground surface (m)
All the waste containing lead	2000	405	5	3

Table 4: Hydrological and hydrogeological properties of the industrial disposal site at TPC

Parameters	Unit	Quantity
Saturated zone thickness	M	50
Hydraulic gradient of saturated zone	-	0.002
Hydraulic conductivity of saturated zone	m/year	3290
pH of water	-	7
Type of soil	-	Fine sand

Table 5: Characteristics of the industrial waste disposal site at TPC

Parameters	Quantity
Lead concentration (ppm)	420
Groundwater table depth (m)	5
Distance to drinking water well (assumed) (m)	150

the computational engine of IWEM. EPACMTP simulates the migration of chemical waste constituents in leachate from land disposal units, through soil and ground water. Tier 1 leachate concentration thresholds were generated using EPACMTP. In a Tier 2 evaluation, the fate and transport simulation is performed directly inside the IWEM tool.

Model input: The model requires three main sets of data and information to evaluate the type of liner to be used for the disposal facility. The model input values for TPC disposal unit are presented in Table 3-5. It is worth noting that the landfill size was estimated based on a 20 year disposal period as foreseen for the operation of the facility.

RESULTS

As stated earlier the model determines the exposure concentration of lead and compares it to the recommended standards based on risk posed to the human health whose drinking water source is the presumed well potentially receiving the contaminated water. The results of modeling in terms of exposure concentration of lead for different liner types are presented in Table 6.

As indicated in Table 6, the concentration of lead determined to occur in the drinking water well is orders of magnitude greater than the standard recommended in accordance with the associated human health risks. Furthermore, even a single clay liner does not seem to provide secure conditions in terms of groundwater contamination to lead. Clearly the composite liner made of High Density Polyethylene (HDPE) along with a clay liner prevents the transport of lead to the downstream drinking water well.

Table 6: IWEM results for exposure concentration of lead for different liner types at TPC industrial waste disposal facility

Liner types	Exposure concentration (ppm)	Lead concentration at the well (ppm)	Groundwater protected?
No liner	0.015	10.28	No
Single clay liner	0.015	2.107	No
Composite liner	0.015	3.2E-16	Yes

CONCLUSIONS AND RECOMMENDATIONS

Industrial wastes generated at the TPC were shown to contain significant concentration of lead. The primary alternative for waste disposal was considered to be landfilling while other measures such as treatment of hazardous components (in this case lead) have not been studied yet. Clearly the priority is to be given to source reduction of lead containing wastes which is of course a matter of feasibility. Secondly it is recommended to treat the waste streams in terms of reducing the lead content so as to avoid further risks associated with lead transport through the land disposal site. However, the safe disposal of the wastes containing lead is to be carried out through employing composite liner. Meanwhile, the use of appropriate final cover to avoid precipitation infiltration could significantly reduce the lead containing leachate. Another measure to be further investigated is to stabilize the lead and other heavy metals using standard stabilization processes such as addition of lime, which could partially immobilize the heavy metals.

REFERENCES

Carson, P.H. and C. Mumford, 2002. Hazardous Chemicals Handbook. Butterworth-Heinemann, USA.

Fletcher, W.K., 1981. Handbook of Exploration Geochemistry 1. Amsterdam, Elsevier Science Publishers B.V. Oxford, New York.

Lagrega, M. D., P.H. L. Buckingham and J.C. Evans, 2001. Environmental Resources Management: Hazardous Waste Management. 2nd Edn. McGraw Hill, New York.

Thomson, M. and S.J. Wood, 1982. Atomic Absorption Methods in Applied Geochemistry. In: Atomic Absorption Spectrometry, Cantle, E.J. (Ed.). Amsterdam: Elsevier Scientific Publishing Company.

USEPA, 1984. Health effects assessment for lead, prepared by the office of health and environmental assessment, environmental criteria and assessment. Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC, EPA/540/1-86/055, NTIS PB85-163996/AS.

USEPA, 1986. Guidelines for carcinogen risk assessment, environmental protection agency. Washington, DC., 51 FR 33992-34003.

USEPA, 1989. Evaluation of the potential carcinogenicity of lead and lead compounds: In support of reportable quantity adjustments pursuant to CERCLA Section 102. Prepared by the Office of Health and Environmental Assessment. Washington, DC. EPA/600/8-89/045A.

USEPA, 2002a. EPACMTP Parameters/data Background Document. Office of Solid Waste, Washington, DC.

USEPA, 2002b. IWEM Technical Background Document. Office of Solid Waste, Washington, DC.

Woodside, D., 1999. Hazardous Waste Management. 2nd Edn. Wiley, New York.