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A CASE HISTORY OF HAZARDOUS WASTE FORMED IN A CHEMICAL PLANT ACCIDENT

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Abstract. Hazardous waste composed of mixture of chemical products, such as partially burned and/or degraded raw materials, semiproducts and final products, and pieces of production hall destroyed in the explosion, estimated to a total of ca 250 tons, was urgently removed from a plant location and disposed in a nearby cement industry yard. Unfortunately, instead of planed 3 to 6 months, it took more than 10 years before the further step towards permanent disposal was realised. During these 10 years a lot of efforts aimed to provide a proper solution that will meet the existing legal, environmental, and other regulations were done. Due to lack of experience, limited finances and other organisational inconsistency, all of the efforts were unsuccessful. Finally, when the temporal site location become an obstruction for cement raw-material mining, a solution was found in dislocation of the provisory landfill to an adjacent but already exhausted corner of the mine field. First of all the existing cell was carefully opened and checked for eventual emission of dangerous gases or vapours. When this possibility was eliminated, the cell was completely opened and samples for physico-chemical testing were picked up. 15 distinguishable samples were taken and tested in the laboratory for leaching in water and evaporation during heating. 5 of these samples were found to be still air, water and/or soil possible contaminants, thus preventing the waste's direct disposal in an open landfill (where interaction with atmospheric precipitations is possible). For this purpose a 3-compartment concrete shell was designed, constructed and made resistant. The waste was transferred into the new disposal location, poured out in the shell, compacted and finally covered with an appropriate concrete plate, thus forming a kind of encapsulated sarcophagus. Thorough safety tips were applied in order to prevent any further accident during the entire procedure. Steps for monitoring any leakage or other possible pollution from the described sarcofagus are planned. One should be stressed out that this is the very first experience in Republic of Macedonia with treatment and legal disposal of hazardous waste.

Keywords: hazardous waste, landfill disposal, procedures for opening and dislocation of a temporary cell.

AIMS AND BACKGROUND

Despite of the permanent care and recent improvements[1,2], safety in the process industry is still far from being perfect. As a consequence, accidents happen that cause death, destruction and pollution. In our minds are still fresh recollection of Seveso[3], Bhopal[4], or recent Baia Mare disasters.

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This paper deals with the environmental consequences of a far minor, but not neglectible incident in Skopje, the capital of the Republic of Macedonia. 14 years ago a blast and fire practically destroyed a chemical plant dealing with products for building industry. The accident caused a number of casualties. A fast action aimed to clean up the damaged plant was immediately undertaken. The entire waste, containing both chemicals/products and production hall pieces, estimated to 250 tons, was disposed in a temporary landfill located in a nearby cement production plant. Ever since a battle with bureaucracy started in a search for permanent disposal solution. It was shown that, due to lack of experience or some other reasons, the authorities were unable to solve the problem. The most frequent excuse for rejecting the request was that they are ready to issue it, but only after someone else will previously make the crucial move. Also again the *"never in my backyard"* syndrome exhibited one of its many faces.

In this paper the experience gained in solving this environmental problem is described.

HAZARDOUS WASTE

According to available data[5], in the moment of accident following products and their components were present in the damaged plant:

- concrete and mortar admixtures;
- surface waterproofing;
- joint sealants;
- epoxide systems;
- anticorrosion additives;
- adhesives and smoothing compounds;
- fire protection materials, etc.

In order to determine the environmental risk, it was decided to analyse the properties of individual raw materials, components of the above products. The list of raw materials, as presented by the factory's management, contains following compounds:

- epichlorohydrine (1-chloro-2,3-epoxypropane);
- silane (silicon hydride, disilane);
- asphalt (bitumen, tar);
- latex (butadien);
- aluminium oxide (alumina);
- monoammonium phosphate;
- bisphenol A (dian, diphenylolpropane);
- diethyl-triamine (2,2′-diamino-diethylamine);
- vinyl-chloride.

Having in mind that it is normal to expect that every producer will keep in secret some of the data (as part of his industrial property protection policy), this list nevertheless delivers enough informations on the diversity of chemicals and the nature of risks in dealing with them. All of above compounds were separately characterised for their physical, chemical and hazardous properties, so that an extended register of their safety data[6,7] was compiled, as described in more details elsewhere[8]. Accordingly, it was concluded that a reasonable risk of contamination exists in case of direct spilling or disposal of such materials.

The fact that many of these compounds were inertised in the course of: (i) the production process, (ii) the fire after the accident, and (iii) the 12 year long degradation process in the temporary landfill, did not affect the care taken in subsequent opening procedure for determination of landfill's actual state.

RISK ASSESSMENT

A risk assessment was the next point before deciding what to do with the residues buried 12 year ago. In order to determine the real danger, a probe excavation was performed. After it was proved that no dangerous gases or vapours escape from the landfill, samples of different products were picked up and subjected to identification and analysis procedure. Only 15 out of the 30 samples were found to be products or raw materials suspected as possible contaminants. They were subjected to accelerated laboratory ageing, in order to assess the environmental risk in case of their open landfill disposal.

Both product's leachability and evaporability were simulated. Leaching was done as 10-20 min boiling in distilled water at the solid-to-liquid ratio of 1:1. Changes of leachate's pH, conductivity and appearance were measured. Evaporation was forced during the 4 h long heating at 80°C. Weight loss and change of sample's surface were analysed.

In Tables 1 to 3 the accelerated ageing results are presented.

Table 1. Leachability of waste's components in boiling distilled water

Sample (trade name)	pH (25°C)	Conductivity (μS/cm)	Leachate's colour
Distilled water (10:1)	6.80	280	clear, colorless
Bitek-F	8.53	1.312	yellowish, opaque
Bitek-PKS	8.52	1.194	yellowish, clear
Bitek-O	8.16	1.970	brown (floating black fatty spots)
Adingpox-I (part A)	8.65	1.820	opaque, small white particles
Plamal-C	5.73	5.700	clear, colourless
Polymer (PO)	8.40	43.400	yellowish, opaque (colloid)
Naphthalene	8.53	1.190	colourless (sublim. particles)

Table 2. Stabillity of waste's components (boiling in distilled water)

Sample (trade name)	Solubility (a.u.*)	Leaching residues
Bitek-F	2	partially hydrolysed (coronet on top)
Bitek-PKS	1	without changes
Bitek-O	2-3	partially hydrolysed (coronet on top)
Adingpox-1 (part A)	1	without changes
Plamal-C	1	without changes (coronet on top)
Polymer (PO)	4-5	volume greatly reduced
Naphthalene	1	sublimates

* Solubility: 1 – slight; 2 – small; 3 – intermediate; 4 – dominant; 5 – complete.

Table 3. Stability of waste's components (evaporation at 80°C, 4h)

Sample (trade name)	Weight loss (%)	Sample's change
Bitek-F	4.3	without change
Bitek-PKS	1.7	without change
Bitek-O	1.6	darkend
Adingpox-1 (part A)	1.7	without change
Plamal-C	28.1	expanded
Polymer (PO)	7.9	without change

According to their appearence, the products listed in Tables 1-3 were previously categorised as incompletely inertised. The measured changes of pH, conductivity and colour in Table 1 confirmed this conclusion. The most pronounced changes were measured in leachats of Polymer(PO) and Plamal-C. In Table 2 Polymer(PO) and Bitek-O were found as the most soluble and in Table 3 Plamal-C and Polymer(PO) were found as the most evaporating products. One should stress out that out of the 7 tested products, only Bitek-PKS and Adingpox 1 (part A) could be rated as practically unaffected by the leaching and evaporating testing. The rest 5 products are air, water and/or soil potential contaminants, so that according to the existing legislative, their disposal in an open landfill is out of law.

SARCOPHAGUS AS THE ACCEPTABLE DISPOSAL SOLUTION

In absence of any hazardous waste treatment facilities, facing an urgent need to render the site location to its original purpose and having in mind the fruitless search for permanent location, we concluded that a sarcophagus is the optimal solution. Having the authority's approval, a 3-compartment concrete shell was designed, constructed and coated waterproof. The site's layout and cross-section are given in Fig. 1. In Figs 2 and 3 photos are given of the real object before and during its filling with the mixture of hazardous waste and soil from the temporal site.

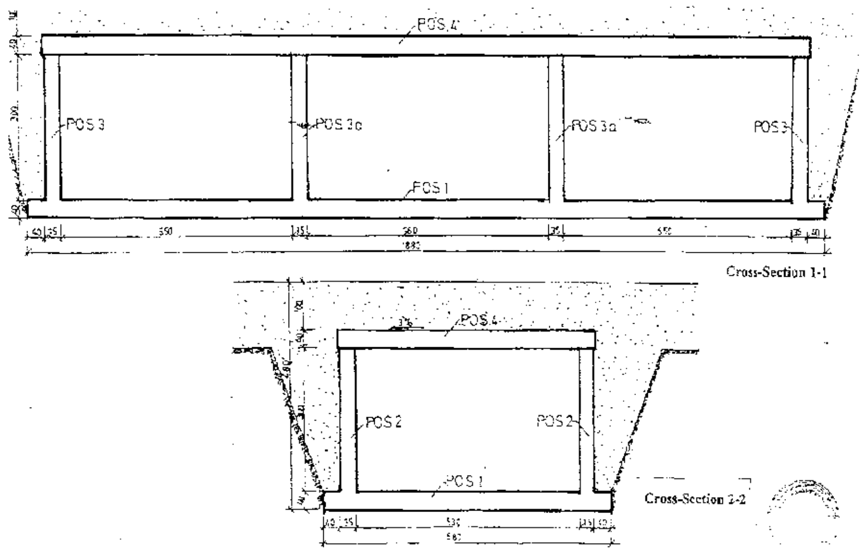

Fig. 1. A schematic of sarcophagus lay-out and cross-section

The waste's removal and transportation were done with maximum care in order to avoid any possibility for further contamination. Finally, the concrete boxes were covered with proper concrete plates, thus forming the planned sarcophagus.

Fig. 2. Empty sarcophagus

Fig. 3. Sarcophagus shell filled with a mixture of hazardous waste and soil

CONCLUSIONS

Instead of conclusions, a list of lessons to be learnt from this case is given in 6 points:

1. Prevent similar accidents by all means!
2. If, despite of all, a similar accident happens again, obligatory apply the "4Rs" principle: reduce, reuse, recycle and recover the hazardous waste prior to any further procedure!
3. Avoid direct disposal of an untreated hazardous waste!
4. Be very cautious about hazardous waste site location!
5. Standardise and make efficient the administrative procedure for hazardous waste management.
6. Build (adopt) an hazardous waste incineration unit. At least!

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