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| Title | POLLUTION OF GROUNDWATER BY LEACHATE FROM DONG THANH LANDFILL DISPOSAL SITE |
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| Citation | Annual Report of FY 2001, The Core University Program between Japan Society for the Promotion of Science(JSPS) and National Centre for Natural Science and Technology(NCST). P.48-P.51 |
| Issue Date | 2003 |
| Text Version | publisher |
| URL | http://hdl.handle.net/11094/13071 |
| DOI | |
| rights | |
| Note | |

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POLLUTION OF GROUNDWATER BY LEACHATE FROM DONG THANH LANDFILL DISPOSAL SITE

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ABSTRACT

A landfill disposal site, by nature, always has environmental impacts; and Dong Thanh is not an exception. Besides the aesthetic deterioration and odours, the pollution of groundwater and surface water is of the most concern, especially where local residents use the waters directly for personal hygiene, washing and drinking. An investigation of the groundwater quality has been carried out to assess the pollution status. Outcomes of this work would be expected to help the government with making appropriate policies to manage the solid waste of the city.

BACKGROUND

The rapid economic growth of Ho Chi Minh city, the country's major industrial and commercial center that currently accounts for about 35% of national GDP, has attracted human force from other provinces. As a result of high population (ca. 7 millions) and increasing living standards the city has been faced the solid waste management problem, approximately 5.500 tons of municipal solid waste are generated a day. In the last 5 years most of the waste from the urban areas are collected and dumped mainly at Dong Thanh landfill site. The remaining capacity of the site is expected to reach its capacity by the end of this year. Therefore, an extension of the existing site up to 130 ha has been proposed to meet the current needs.

Current situation of Dong Thanh landfill site

Dong Thanh is 25 km north from the urban center and is located in an area previously used to borrow clay for filling of low lying construction sites in Ho Chi Minh city. The land has natural slope from an elevation of about 12 m at the southern boundary to 2m at the northern. Nearly 4000 tons of municipal solid waste are dumped a day without screening into big cells of ca. 8-10m deep and 150m wide. Dump places are covered with the soil from these cells in approximately weekly period. The site is isolated from the surroundings by a 3m high embankment on its south, east and west sides. On the north side headed to Tra Cannal, a 4m high dike was constructed with material of clayish and sandy loam. The dike is 9m wide at the bottom and 4m at the top. Though the dumping operations have been improved due to public pressures there are complaints about the odours and leachate leaking. In fact, no gas collection system has been installed and the leachate treatment plant has not been operated yet. Leachate is collected in ponds in dry season but contaminated rainwater runoff in wet season was discharged directly into small canals leading to Tra canal to prevent the embankment from falling down.

The use of groundwater in the surroundings of the dump site

The local residents use dug wells (7- 12m deep) for irrigation and drilling wells (> 40m deep) for household activities. Only few houses in nearby areas next to site have access to limited amount of clean water provided free of charge by the local government.

QUALITY OF THE GROUNDWATER AT DONG THANH DUMP SITE

Sampling

Water samples were collected from available wells either of local residents or from drilling wells inside the site which have been used for environmental monitoring only. Leachate from a collection pond inside the site was also taken for analysis. There are only dug wells (7-12m) in the north of the site for irrigation purposes and on the remaining sites there are drilling wells (30-40m) mainly used for household needs. Approximately 1m³ of water was pumped out before taking the samples. pH, DO and TDS were measured at the site. The samples were treated with appropriate chemicals and analyzed immediately after transporting to the laboratory.

Sampling locations are shown in the following table:

| Sample | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|-----------|---------|-------|-------|-------|--------|----|---------|------|-------|--------------------|
| Depth (m) | 7-12 | 7-12 | 7-12 | 7-12 | 23 | 39 | 70 | 60 | 40 | in collection pond |
| Location | north | north | north | north | inside | | east | west | south | inside |
| | outside | | | | | | outside | | | |

Analytical results

Levels of typical items, represented pollution status of water samples, are shown in the table below. To assess the groundwater quality, Vietnam National Standards for groundwater (TCVN 5944- 1955) are referred. They are printed in bold in the first row of the tables. For items that are not mentioned in TCVN 5944- 1955 the TCVN5942- 1955 which is for grade A-surface water (running water supplies after treatments) are used instead. They are also in the first rows with (*)

| Sample | pH | Phenols (µg/L) | NH ₄ ⁺ -N (mg/L) | NO ₂ ⁻ -N (µg/L) | NO ₃ ⁻ -N (mg/L) | COD (mg/L) | BOD ₅ ²⁰ (mg/L) | DO (mg/L) | TDS (mg/L) | Coliform (MPN/100ml) |
|--------|------------------|-------------------|---|---|---|-------------------|--|---------------|-----------------|-------------------------|
| | 6.5 - 8.5 | 1 | 0.05 (*) | 10 (*) | 10 (*) | <10 (*) | <4 (*) | ≥6 (*) | 750-1500 | 3 |
| S1 | 5.71 | ND | 9.6 | 18.3 | 1.42 | 12.0 | 8.0 | 1.3 | 32 | 2.4 x 10 ⁴ |
| S2 | 5.38 | ND | 48.1 | 155.9 | 0.37 | 103.2 | 65.3 | 1.1 | 713 | 2.3 x 10 ² |
| S3 | 4.51 | 30.6 | 7.4 | 6.2 | 0.14 | 16.8 | 12.0 | 0.9 | 93 | 4.6 x 10 ³ |
| S4 | 4.14 | 13.2 | 2.68 | 52.2 | 1.05 | 40.8 | 25.2 | 3.2 | 222 | 1.1 x 10 ⁴ |
| S5 | 5.98 | ND | 98.8 | 5.5 | 0.10 | 79.2 | 55.0 | 0.6 | 466 | <10 |
| S6 | 5.71 | 4.9 | 67.7 | 5.5 | 0.03 | 134.4 | 79.0 | 0.4 | 660 | <10 |
| S7 | 5.23 | ND | 0.1 | 46.8 | 1.72 | 7.2 | 2.4 | 4.0 | 13 | 4.0 x 10 |
| S8 | 5.07 | 27.8 | 0.28 | 8.9 | 0.71 | 9.6 | 2.1 | 4.3 | 8 | <10 |
| S9 | 5.03 | ND | 0.1 | 6.9 | 0.51 | 9.6 | 1.9 | 5.0 | 7 | <10 |
| S10 | 10.0 | 240.9 | 385.8 | ND | 0.12 | 2200.0 | 1320.0 | 0.0 | 19350 | 9.3 x 10 ⁵ |



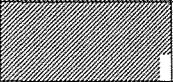
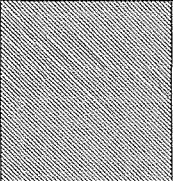
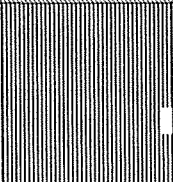
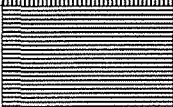

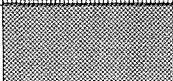
The results indicate that

- All groundwater samples from shallow wells are heavily polluted with bacteria and organic matters presented by high levels of BOD, COD, NH₄⁺, NO₃⁻ and coliform.
- Water from drilling wells of more than 50m deep are only slightly polluted.
- Heavily metals present at insignificant levels in all samples.
- Two drilling wells located inside the site are seriously polluted with organic matters.

| Sample | Cu (µg/L) | Pb (µg/L) | Zn (mg/L) | Cr (µg/L) | Fe (mg/L) | Cd (µg/L) | Al (mg/L) | Hardness (CaCO ₃) (mg/L) | Cl ⁻ (mg/L) | PO ₄ ³⁻ (mg/L) |
|--------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|---------------------------|---|
| | 1000 | 50 | 5 | 50 | 1 - 5 | 10 | | 300 - 500 | 200 - 600 | |
| S1 | 2.7 | 9.10 | 0.1346 | 10.96 | 2.59 | 0.114 | ND | 100 | 41.35 | 0.441 |
| S2 | 10.6 | 6.51 | 0.0245 | 9.42 | 31.14 | 0.285 | 7.74 | 970 | 956.42 | 0.067 |
| S3 | 5.0 | 2.34 | 0.1231 | 0.82 | 15.14 | 0.268 | 0.20 | 90 | 89.60 | 0.140 |
| S4 | 3.6 | 3.64 | 0.1469 | 4.44 | 1.095 | 0.289 | 0.90 | 89 | 303.2 | 0.083 |
| S5 | 4.2 | 3.06 | 0.0108 | 4.17 | 65.94 | 0.081 | 0.0069 | 1350 | 468.6 | 0.0195 |
| S6 | 4.8 | 6.55 | 0.0271 | 6.70 | 48.65 | 0.165 | 4.73 | 204 | 76.68 | ND |
| S7 | 7.5 | 2.50 | 0.0082 | 0.36 | ND | 0.064 | 0.31 | ND | 21.53 | 0.156 |
| S8 | 3.5 | 1.36 | 0.0089 | 0.72 | ND | 0.046 | ND | 6 | 26.71 | 0.042 |
| S9 | 5.1 | 0.97 | 0.0112 | 0.36 | ND | 0.020 | ND | ND | 10.34 | 0.050 |
| S10 | 1.3 | 6.58 | 0.3007 | 145.3 | 12..30 | 0.216 | 1.25 | 2187 | 2769 | 11.81 |

Geologic investigations of Dong Thanh landfill site

Bore hole stratigraphic column (DT1)

| Geologic Age | Depth of layer (m) | Thickness of layer (m) | Stratigraphic column | Description |
|-------------------|--------------------|------------------------|---|---|
| Q _{IV} | 2.0 | 2.0 |  | Clayish loam, yellowish grey |
| | 3.5 | 1.5 |  | Clayish loam with gravel, yellow |
| Q _{I-II} | 8.0 | 4.5 |  | Clayish loam, light grey, yellow |
| | 20.0 | 12.0 |  | Sandy loam, fine, yellowish grey, light purple, quick ground |
| | 35.0 | 15.0 |  | Sand, coarse & medium, with gravel yellowish grey, light grey, semi-rigid |
| | 42.0 | 7.0 |  | Sand, fine & medium, yellowish grey, semi-rigid |
| | 44.0 | 2.0 |  | Sand, coarse & medium, yellow |
| | 50.0 | 6.0 |  | Clayish loam, purple, yellowish grey, rigid- semi rigid |

Investigations into geologic formation at Dong Thanh site [1] shows that:

- The surface is covered by a clay layer down to 7-10m deep.
- Under the clay layer is a sand bed (from 11- 40m deep) where the first groundwater zone locates, and so does the interface between the waste and the soil. It should be noted that no synthetic impermeable liner has been installed to prevent the leachate from infiltrating into the soil below.
- The next is another clay layer (ca. 7m thick). However, in two of five boreholes there is no clay bed at the depth. Since this bed serves as an impermeable material between the first and the second groundwater zones it is possible for pollutants to disperse between the two zones in some positions at the dump site.

A typical bore hole stratigraphic column is presented in the figure.

Determination of permeability of sand bed (8-12m deep) [2] gives the mean value of 0.204 m/day which is high by far the standards accepted by many countries for a natural impermeable layer. That is 10^{-7} m/s or 8.6×10^{-4} m/day and the thickness of the bed must be higher than 0.9m [3]. In addition, the permeability of the dike material is also too high (0.192m/day)

CONCLUSION AND RECOMMENDATIONS

Conclusion

- The first groundwater zone (15-30 m deep), by all appearances, is *heavily polluted by leachate* from the solid waste since the permeability of the soil at the bottom of the dump cells is too high and there is no synthetic impermeable liner to isolate the solid waste from the soil below.
- It appears likely that the second groundwater zone (50-70m deep) starts to be polluted because the clay bed between the two zones does not distribute evenly.

Recommendations

- *To the existing landfill site:* in order to reduce the pollutant infiltration into the groundwater, it is necessary to collect the leachate more effectively and to treat it with the existing treatment plant before discharge. In wet season this operation must be done more intensively to prevent the contaminated rainwater runoff from running over where the dike or embankment is broken by its pressure. Such accidents have been occurred a number of time and have caused many complaints.
- *To the extension plan of Dong Thanh landfill site:* it should not be done unless no more places available. The reason is the proposed land for the extension is located in flood prone land between the existing site and Tra Canal which flows into Saigon river approximately 1 km east of the site. Otherwise, more sanitary operation procedures must be follow e.g. lining the dump cell with polymer membrane, covering the waste with soil more often before the last cover with impermeable material on the waste fill is applied, installing effective leachate collection and treatment systems.

References

1. Vietnam Geologic Department - Geologic Division No. 8
2. Dr. Huynh Ngoc Sang and coworkers, Faculty of Geology - Ho Chi Minh University of Natural Sciences.