Review of the nature and type of hazardous waste polluted sites in India
Key output Final Report Task 1
Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Ministry of Environment and Forests, Government of India, Delhi
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Executive summary

General
This report presents the key output of the activities carried out under Task 1 (Review the nature and type of hazardous waste polluted sites in India) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Objective and report content
The objective of Task 1 is to review the available inventory on hazardous waste contaminated sites and understand the nature of contaminated sites in India. This insight was used to develop a typology of probably contaminated sites in India, suited for the identification and selection of remediation strategies in Task 3. We define ‘typology’ as ‘The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites’. This report offers a typology covering all contaminated sites as described in the database developed in Assignment 1 (‘Inventory and Mapping of Probably Contaminated Sites in India’). The inventory of available data was used to get thorough insight in the nature and types of contaminated sites in India as well as to validate the typology and the database. The developed typology is robust, offering the possibility for sites not yet inventoried to fit in.

Data sources
The available version of the inventory on hazardous contaminated sites was consulted and analysed. As the database to be developed in Assignment 1 was not yet available when we started working on this task, we have used initially:

- available data sources from CPCB (including data provided to them by SPCB’s and PCC’s), and the Blacksmith Institute;
- several literature references;
- the results of site visits conducted by members of the project team;
- and the results of our review of international approaches for remediation of contaminated sites, as conducted in Task 2 of this project.

Results

- Site visits conducted by members of the project team (described in chapter 5) resulted in information directly from the field, to strengthen the development, selection and prioritization of realistic remediation options, taking into account practical limitations;
The Typology (described in Section 6.4) distinguishes the following main types of contaminated sites:

- **Source related:**
  - Type S1: Land bound solid phase contamination
  - Type S2: Water bound sediments solid phase contamination
  - Type L: Land bound liquid phase contamination
- **Pathway related:**
  - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
  - Type P2: Groundwater contaminations

Depending on the specific situation, a site may fit into more than one of these types;

- subtypes are defined (see table 6.1 in Section 6.4);
- data needed to designate a site to a specific type are listed (Section 6.5);
- classification of identified sites within the typology (Section 6.6).

**Conclusions**

Care has been taken to make sure that the scope of the typology includes at least the sites included in the data sources mentioned above. The developed typology, described in Section 6.4, is generic and robust, so that it is expected that any contaminated or potentially contaminated site identified in India, including sites that are not yet present in existing site inventories, can be classified within its scope. The typology is based on activities and geometry of the contamination to be used when developing a site assessment strategy. Combined with site specific information on chemical substances and soil characteristics, this typology will be used to get insight in realistic remediation options (to be developed for each type of site in Task 3) to support the user of the Guidance document (to be developed in Task 4) in the process of remediation option appraisal.

**Remarks**

- Available data for several sites is too poor to make a detailed analysis of the spreading of contamination, risks and remediation options or to allocate those sites to a specific site type;
- Data from the Inventory (Assignment 1) can be used to validate the developed typology. We have offered the standard site factsheet and typology to give the Assignment 1 project team the opportunity to make the database fit for linkage with the typology and Guidance document. We plan to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. A tentative validation against a draft version of this database of 13th December 2012 made clear that all sites in this version of the database, except the sites where contamination is limited to surface water, could be assigned to a type within the typology. In some cases multiple types are assigned to a site. The structure of the typology allows this multiple assignment. We will include the results in of the validation against the final version of the database in the final report of this project, to be developed in Task 6. In case the validation results in the need to apply changes to the results of Task 3 (Review of remediation options) and Task 4 (Guidance document); these will be dealt with in detail in the same final report.
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Note: Annexure 4a, containing the standard site factsheets on the sites mentioned in annexure 4, is presented in a separate annexure report to this report.
1 Introduction

1.1 General
This report presents the key output of the activities carried out under Task 1 (Review the nature and type of hazardous waste contaminated sites in India) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

The report presents the results of steps 1.1 to 1.5. Earlier drafts of this report were presented to and discussed with the Technical Expert Panel (TEP) on June 28th and August 13th, 2012. An earlier draft of this report was presented to and discussed with the World Bank and MoEF on 30th November 2012. An earlier draft of this report was presented to the project teams of the Assignments 1 and 3 on 10th December 2012. The comments by the TEP, the World Bank, MoEF, and the project teams of the Assignments 1 and 3 referring to this Task have been implemented in this final version of the report.

It is important to note that the development of the NPRPS is at a very early stage at this time, and that therefore this Assignment, along with the parallel Assignments 1 (Inventory and mapping of sites) and 3 (Development of NPRPS), will provide the very basis for its further development. As this process will continue, during these Assignments and perhaps even more so after their completion, new findings may change the perspective on the results of all three Assignments. Hence, we see the development of the NPRPS as a process of growth, in which the results of earlier projects like this one may have to be reviewed periodically in later stages.

1.2 Objectives Task 1
The objective of Task 1 is to review the available inventory on hazardous waste contaminated sites and understand the nature of contaminated sites in India. The Key output is this report, presenting both a thorough insight in the nature and types of all contaminated sites in India as well as specifications for the database to be developed in Assignment 1 (‘Inventory and Mapping of Probably Contaminated Sites in India’) and a typology of probably contaminated sites in India, suited for the identification and selection of remediation strategies in Task 3.

For these objectives in this task the available inventory on hazardous contaminated sites is inventoried and analysed. This step is the very basis for the development of remediation options, which will be addressed to the different types of sites in the field. With that, the development of a typology of contaminated sites is an important step towards effective priority setting of remediation options.
1.3 Basic assumptions
The activities of Task 1 are based on the following basic assumptions.

Definitions
The definitions for Contaminated and Probably contaminated site are given by the Client. The original draft version, provided by the Client on 30th July 2012, was revised. We have used the revised definitions, sent by the Client to the Assignment 1 project team in January 2013, and refer to Annexure 1 for this definition.

Data sources
Only site related data provided or approved by the Client are used. A list of used data is shown in Annexure 2. Types of contaminated sites for which we have received no information provided or approved by the Client have not been incorporated in the typology.

It is generally acknowledged that the best basis for the development of a Typology is the database to be developed in Assignment 1. As this database could not be available at the outset of the project we have developed the typology described in this report on the basis of whatever data, meeting the criteria described above, was available. On 17th September 2012 the Blacksmith Institute kindly granted our project team access to their database ‘Toxic Sites Identification Program, Global Database’, the most comprehensive known database on contaminated sites in India to date. Before that we had already developed draft versions of this report, based on the rather limited data available until that time. We then proceeded to incorporate the results of our study of the Blacksmith database into this report. On 13th December 2012 we received a draft version of the inventory of sites from Assignment 1. After discussion for alignment with the Assignment 1 project team we then proceeded to incorporate that version of the inventory into this report.

1.4 Activities in Task 1 and reading guide
We have carried out the steps in Task 1 as described in the Contract for Consultants’ Services (26/03/2012) and the report follows these steps:

- Step 1: Quick scan of existing local inventories of contaminated sites
- Step 1.2: Blue print of the typology of contaminated sites and list of data needed to comprehensively describe the types of sites
- Step 1.3: First analysis of database developed in Assignment 1
- Step 1.4: Site visits
- Step 1.5: Final analysis of the Typology

Note: Step 1.6 - Draft report typology of contaminated sites, constitutes the present report.
Step 1.1 - Quick scan of existing local inventories of contaminated sites

2.1 Data sources
When starting the project the database of Assignment 1 was not available yet. Therefore, a first impression of the types of contaminated sites was made using existing site inventories. It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. Please refer to Section 6.6 for more information on the validation of the typology. The following inventories were made available by the client for this purpose:

- List of 12 priority contaminated dump sites (CPCB, no specific reference, Annexure 6);
- List of 25 hazardous waste dump sites (CPCB, no specific reference, Annexure 7);
- Reports available for some of these sites.

During the TEP meeting on June 28th, 2012, the following reports were mentioned as useful for this Task and were studied subsequently:

- ‘Polluted Sites - India’ (Blacksmith institute, 2007);
- ‘A compilation of polluted places India; Initial site assessment reports’ (Blacksmith institute, 2007);
- Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit (UNIDO, 2009);

An overview of site related data provided or approved by the Client is presented in Annexure 2.

2.2 Standard site factsheet
As a first step in developing the typology a standard set of elements was made to analyse the site data. This standard set, based on the best practices and consultant’s experience, is used for a systematic analysis of these dossiers and to list data that could be significant for a comprehensive description of all site types. Depending on the dossiers not all elements will be distinctive for the typology. E.g. in case a non-soluble contaminant is dumped, the information on the geology will not be distinctive for the typology or for the remediation strategies.
The purpose of the assessment was not to make a complete description of all these sites (this task is carried out in assignment 1), but to enable the development of a comprehensive typology. Based on this assessment a typology was developed. Conducting a quick scan on the inventories mentioned above resulted in an overview of the most important site characteristics, such as size, chemical content, probable spreading of pollutants, risks, geographical and potential social aspects. To present these characteristics effectively a standard site factsheet was developed.

This standard site factsheet was developed also bearing in mind the following steps in the project:

- Interaction with assignment 1. E.g., using the database developed in Assignment 1 it should be possible to generate a list of all sites of a specific type;
- Select sites for site visits. The site factsheets give more detailed information to make a more confident selection of the sites to be visited;
- Identify standard options and recommended standards for remediation of contaminated sites in Task 3. In that task a menu of remediation options is developed based on the Typology;
- Give a focus for the Task 2 review of the national and international approaches.

In the Task 2 report of Assignment 2 it is concluded that the ‘source-pathway-receptor’ concept is the cornerstone of contaminated land remediation policy and practices in many countries like the UK, the US and The Netherlands. Therefore, the standard site factsheet (figure 2.1) contains general data of the site and site related data based on this concept. Also, the Typology, as described in Section 6.4 in this report, and the Guidance document (site assessment and option appraisal, to be developed in Task 4) will be based on the ‘source-pathway-receptor’ concept, so as to align the methodology with international practice. Please refer to the following textbox for more detailed backgrounds to the source-pathway-receptor concept.

### Source – Pathway – Receptor concept

The ‘Source – Pathway – Receptor’ (SPR) data meet a fundamental and internationally widely accepted approach. The three elements of this concept are:

- Source: The cause or source of the contamination is identified. For example, the source might be a leaking oil tank or a layer of pure oil in the topsoil, leaching into an emerging contaminated plume in the groundwater.

- Pathway: The pathway is the route the source takes to reach the receptor. Pathways include, for example, air, water, soil, animals, vegetables and eco-systems.

- Receptor: If contamination is to cause harm, it must reach a receptor. A receptor is a person, animal, plant, eco-system, property or a controlled water. Each receptor must be identified and their sensitivity to the contaminant must be established.

The concept is used in risk assessment to identify the source of any contamination, what the source may affect (receptor) and how the source may reach the receptor (pathway). Conclusions are drawn on the potential risks caused by the source of contamination. Conceptual models are commonly used to implement a structured and ef-
Step 1.1 - Quick scan of existing local inventories of contaminated sites

Efficient investigation. Where the concept is used to develop remediation options, the remediation techniques can be designed in such a way that the effects meet an optimum, e.g., by balancing the intensity of a technique over the three elements of a specific site. For example, removing most, but not all, of a source will significantly reduce leaching from the source. This will not remove, but will stop the growth of the plume of contaminated groundwater (pathway), thereby necessitating some long term remediation action.

Adverse effects, and thereby the need for soil remediation, only occur when the following three elements are present:
- **Source** = potential hazard, e.g., a toxic chemical or other agent;
- **Pathway** = connection between source and receptor;
- **Receptor** = target for protection (human life, ecosystem, resources (water and land)).

The exact situation regarding these SPR-elements not only determines the need to remediate, but also the focus and with that the potential types of remediation options.

The impact for the Typology is that it is not technology driven but methodology driven. This methodology will be an important element of the Guidance to be developed in Task 4 and lead the user through the process of analyzing and investigating a contaminated site, assessing risks and designing a remediation approach which will address these risks. In this process techniques are just (but very important) tools to reduce the risks and are not seen as targets by themselves.

We can illustrate the concept of a methodology driven Typology by the following example case.
- **Site description**: hazardous waste dumpsite;
- **Risks**: direct human contact;

Remediation options only focused on the risks at hand: [1] removal of the waste by excavating and Secured Landfill (SLF) storage, [2] removal of the waste by using in situ techniques or [3] capping the waste using a clean soil top layer. These remediation options offer three different generic methods for remediation without going into the details of the specific techniques to be applied. Each option offers a solution which meets a different set of criteria and objectives (e.g., time available to reach the remediation goal, future land use target concentration).

Once the selection of the most applicable remediation option is carried out the most favourable remediation option can be detailed out into a remediation strategy. At this point a specific technique can be selected out of a wide variety of techniques. For example, an in-situ technique specifically applicable to the local conditions, possibly after some pilot testing. Using this top-down approach from method to technique it is most likely that the selection process will result in the most favourable remediation strategy in a most transparent and effective way.

---

**Figure 2.1** Standard site factsheet

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Explanation</th>
<th>Actual description</th>
<th>Data quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>General data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
### Aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Explanation</th>
<th>Actual description</th>
<th>Data quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrain</td>
<td>Coastal, delta, mountainous,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use</td>
<td>Urban, industrial, rural, nature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility / infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to contractors / authority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreading zone: urban-industrial-rural-nature…</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SOURCE

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Physical properties</th>
<th>fluid / solid / solubility / volatility</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Position in soil</td>
<td>on the surface / in soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity</td>
<td>homogeneous / heterogeneous / brown-field</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Origin of the deposit</td>
<td>dump / leakage / fluvial deposit (sediment) / areal deposit / storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period of contaminating</td>
<td>First and last year soil was affected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Origin of contaminants</td>
<td>what type of industry or activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical type of tailings</td>
<td>sludge, tailing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical chemical composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration in topsoil</td>
<td>average concentration per parameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of contaminated soil</td>
<td>m3 / mmt (source in soil or HW deposited)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area contaminated soil</td>
<td>Acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration in groundwater</td>
<td>average concentration per parameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume contam. groundwater</td>
<td>m3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area contam. groundwater</td>
<td>Acre</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PATH

| Geology / Geohydrology | sand/clay/bedrock/… |                                        |                    |              |
| Depth water table      | m below surface     |                                        |                    |              |
| Depth bedrock          | m below surface     |                                        |                    |              |
| Permeability topsoil   | low/mod./high       |                                        |                    |              |
| Permeability aquifer   | low/mod./high       |                                        |                    |              |
| Groundwater flow       | direction / speed   |                                        |                    |              |
| Process of spreading   | yes / no            |                                        |                    |              |
| Groundwater flow       | yes / no            |                                        |                    |              |
| Washing                | yes / no            |                                        |                    |              |
| Evaporation            | yes / no            |                                        |                    |              |
| Flooding               | yes / no            |                                        |                    |              |
| Contaminants are subject re-working by human as raw material (reuse) | yes / no |                     |                    |              |
| Surface water flow     | yes / no            |                                        |                    |              |
| By seawater            | yes / no            |                                        |                    |              |
| Typical frequent natural disasters       | flooding, monsoon, washing  |                     |                    |              |

### THREATENED OBJECT

| Exposure to contaminants |                                        |                    |              |
| Direct human contact during presence on contaminated site |                                        |                    |              |
| Groundwater use         |                                        |                    |              |
| Ingestion of crops      |                                        |                    |              |
### Aspect

<table>
<thead>
<tr>
<th>Contact surface water</th>
<th>Explanation</th>
<th>Actual description</th>
<th>Data quality *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social / economical aspects</td>
<td>Social sensibility land user(s)</td>
<td>Organization and motivation</td>
<td></td>
</tr>
<tr>
<td>Awareness</td>
<td>Low/high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of buildings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possibilities of temporary site clearance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of site</td>
<td>Low/high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisory prevention measures already implemented</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access restriction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liners / covers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restrictions to land use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data / information used</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* poor/high, fact /expert guess

Note. We have offered the Standard Site Factsheet and typology to give the Assignment 1 project team the opportunity to make the database fit for linkage with the typology and Guidance

This standard site factsheet was used to give the project team members a first impression of contaminated sites and to analyze the dataset. Data on sites with great similarity to other sites are incorporated in a single standard site factsheet and sites with poor data are skipped altogether. For a comprehensive analysis of all sites, the database of Assignment 1 can be used. These standard site factsheets were also used to select sites for site visits and finally to develop the typology. It should be noted that the standard site factsheet has not been developed to be a final product as such. It is only shown in this report to give insight in our working process. Additional site characteristics can be added to the standard site factsheet as presented above to anticipate to Assignment 1 or 3 activities or for the implementation of the remediation program itself. Those additional site characteristics are not needed for Assignment 2 and the analysis of the typology.

Examples of characteristics that could be added to the site factsheet are:
- Physical address of site;
- Coordinates (Lat/Lon);
- Owner address or status as orphan site;
- Contact person and his/her contact details;
- Responsible local authority, including contact details;
- Access restrictions (administrative, physical/artificial (e.g. fenced) or natural);
- PPE required/recommended for site visit;
- Inside/adjacent to/outside protected area (including type);
- Dumping on-going/finished;
- Type of industry.
2.3 Evaluation of step 1.1

Annexure 4 presents an overview of the sites analyzed using the standard site factsheet. A summary of characteristics of these sites gives some insight in sites identified in India. However, these sites cannot be regarded as showing a representative cross-section of contaminated sites in India. For this the Assignment 1 database, which will show a more representative image of all sites in India, is needed. That database will therefore be used to validate the generic typology described in this report. Please refer to Section 6.6 for more information on the validation of the typology. Until we can carry out that validation we need to limit ourselves in this section to a first impression of the sites listed in the sources we have been able to consult so far.

On the sites listed in these sources, a variety of contaminations is found, such as chromium in various forms, lead, cadmium, pesticides, fluorides, arsenic, mercury, and sulphur dioxide. The sources also include sites with multiple contaminants, and, often the same, sites with contamination from multiple sources. In the latter case often several contaminated spots have been identified in a larger area, e.g. on industrial estates, or a contaminated groundwater plume has been ascertained downstream of a multitude of (former) small industrial activities. In the lists, sites situated in various settings (urban, industrial, rural) are represented. Ownership or polluter are not known in all cases, indicating there will certainly be orphan sites among the sites listed. Several cases resulted in a contaminated groundwater plume.

The Blacksmith institute initial site assessment report is available for 34 sites, but the analytical details are not available for all of those sites. Most of the analytical results indicate contaminants below permissible level, if related to US-EPA, World Health Organization (WHO) or Bureau of Indian Standards (BIS) limits, except known sites like Bicchadi. Sampling was not done at several sites, among which the TCCL site. From the report one additional type of site was derived (type S2, see chapter 6), but – as the report gives limited site specific data – this type could only be described on a very basic level.

2.4 Conclusions drawn from step 1.1

- Available data for some specific sites are adequate to make a quick scan analysis of site characteristics, spreading of contamination, risks and remediation options, so as to get a first impression of contaminated sites to be assessed with the NPRPS;
- The inventory and analysis gives a first and valuable impression of the sites which should fit in the typology to be developed;
- Data from the Inventory (Assignment 1) is used as a validation to the generic typology to be developed in step 1.5. In this process the standard site factsheet (figure 2.1) is to be evaluated by the Assignment 1 project team.

The overview in Annexure 2 was used by the project team as a basis for planning the next step, Step 1.2.
3 Step 1.2 - Blue print of the typology of contaminated sites and list of data needed to comprehensively describe the types of sites

Based on the contaminated site overview created in Step 1.1 and presented in Annexure 2 a blue print typology of contaminated sites in India was developed. This ‘bottom up’ blue print typology was based on an analysis of site specific data.

Discussion with representatives of MoEF, CPCB, TEP and several SPCB’s led to the conclusion that this approach would not result in a generic typology, which would be robust enough as to include sites not yet mentioned in the database. Subsequently, this ‘bottom up’ typology was thoroughly revised in step 1.5, resulting in a top down approach. The result is a robust generic Typology, covering all possible types of sites, including sites that may only be found in other countries. This top down approach should therefore be fit for all contaminated sites in India, either inventoried in step 1.1 or beyond.

This latter approach is accepted as a useful tool for the guidance.

As the revised typology is more generic and applicable to all probable sites not yet included in available inventories the blue print typology as was presented in earlier drafts of this report is not shown in this report.

We refer to chapter 6 of this report for the results of these steps.
When we started writing this report a database from Assignment 1 was not yet available.

Around the time of the June TEP meeting the project teams of Assignment 1 and 2 met and discussed mutual relationships between the Assignment 1 database and the Assignment 2 typology.

We agreed to cooperate wherever possible with the aim to maximize the coherence between the results of Assignment 1 and 2:

- The typology developed in Assignment 2 must be applicable to the database developed in Assignment 1. Using the right queries, all sites of a specific type should be reported from the Assignment 1 database. To make this possible the standard site factsheet (figure 2.1) will be evaluated by the Assignment 1 team. This procedure will ensure that the database developed in Assignment 1 will be ‘fit for purpose’, securing its use on a day to day basis, and thereby making it a valuable and sustainable asset that can serve an effective performance of the NPRPS for years to come;
- The database developed in Assignment 1 will give the Assignment 2 team insight in the complete scope of sites and will thus be the dataset the final typology should cover;
- Conforming to one of the TEP comments on the Inception Report, we have gone ahead with this component, based on the available information of contaminated sites. Whenever a complete inventory of contaminated sites is available, the same shall be used to frame the methodology of contaminated site assessment and remediation options. As agreed, the team of Assignment 1 has made a first draft version of the database available to our team. It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. Please refer to Section 6.6 for more information.
5  Step 1.4 – Site visits

During the initial phase of the project the project team carried out visits of select sites, representing the main types of sites, across the entire scope of the typology as developed up to this point. The aim of these visits was to get to the basis of understanding the nature of contaminated sites in India. New information coming out of this step is used in step 1.5 to fine tune the blue print typology towards its final form, to develop a reliable basis for risk assessment and to evaluate the practical applicability of remediation techniques taking site specific geographical circumstances into account.

During the site visits interviews with local authorities were conducted and where possible with other parties involved. The aim of these interviews was to gather input directly from the field for important operational aspects in the selection of remediation options, communication strategies and socio-economic aspects. This input will considerably strengthen the development, selection and prioritization of realistic remediation options, taking into account practical limitations.

Table 5.1 and figure 5.1 present an overview of sites which were visited by members of the project team. These sites were selected based on the following criteria:

- Priority as well as non-priority;
- Different types;
- Good initial data;
- Geographically spread;
- Different PCB’s.

### Table 5.1  Overview of visited sites

<table>
<thead>
<tr>
<th>Site</th>
<th>State or UT</th>
<th>Date of visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noor Muhammad Kunta</td>
<td>Andhra Pradesh</td>
<td>11.01.2012</td>
</tr>
<tr>
<td>Wazirpur Industrial Estate CETP and Badli Industrial Area CETP</td>
<td>Delhi C.R.</td>
<td>11.04.2012</td>
</tr>
<tr>
<td>Ranipet</td>
<td>Tamil Nadu</td>
<td>26.06.2012</td>
</tr>
<tr>
<td>Hooghly</td>
<td>West Bengal</td>
<td>02.07.2012</td>
</tr>
<tr>
<td>Nibra Village</td>
<td>West Bengal</td>
<td>02.07.2012</td>
</tr>
<tr>
<td>Dhapa, Kolkata</td>
<td>West Bengal</td>
<td>03.07.2012</td>
</tr>
</tbody>
</table>
Results of step 1.4

Of each site visit a report was made. These reports are presented in Annexure 3.

The site visits, the interviews, and site specific data provided by MoEF and SPCB’s resulted in valuable background information for step 1.5 (see chapter 6) and for Tasks 4 and 6. e.g.:

- The site visit results are used to verify the Typology (see chapter 6);
- Information directly from the field, to relate the remediation options to be developed to situations actually encountered in India. Discussions with representatives of the local PCB gave detailed background information on the practical applicability of remediation options, e.g. regarding the possibility of removal under constructions or roads, specific conditions to be considered when generating remediation options, such as the importance of social aspects and site ownership. E.g. Pilot remediation plans and provisional remediation assessments are often focused on the applicability of a single technique without an adequate option appraisal assessing the best remediation strategy fit for purpose. Remediation of urban areas is a delicate process when rehousing is inevitable. In some cases economical aspects that exceed the scope of a contaminated site may play a role in the decision making for the remedial approach;
- First hand information on Sanitary Landfill as a destination for excavated contaminated soil, e.g. capacity, potential for the development of new sites, level of experience in India in design, building and exploitation of sanitary landfills At present the sanitary landfill capacity for contaminated soil is restricted. On the other hand expertise on design, construction and exploitation of such sites is present (e.g. the TTCWMA landfill site);
- First hand information on the capacity of PCB’s, local experience and insight in remediation practices and organisations playing a role in the remediation, such as laboratory facilities. E.g. on the Ranipet site a pilot soil remediation and monitoring has already been carried out;
- Some sites are characterized by a series of similar subsites of the same type, distributed over a restricted area (e.g. Nibra village and Hooghly).
- The results of step 1.4 give a good basis for more detailed and focussed interviews to be held in Task 4.
Figure 5.1  Overview of visited sites

Legend

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Office or site visited</th>
<th>State / UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>office MoEF</td>
<td>Delhi</td>
</tr>
<tr>
<td>002</td>
<td>office CPCB</td>
<td>Delhi</td>
</tr>
<tr>
<td>003</td>
<td>office DPCC</td>
<td>Delhi</td>
</tr>
<tr>
<td>004</td>
<td>site Wazirpur Industrial Pollution Control CETP</td>
<td>Delhi</td>
</tr>
<tr>
<td>005</td>
<td>site Badli Industrial Estate CETP Society</td>
<td>Delhi</td>
</tr>
<tr>
<td>006</td>
<td>office WBPCB HQ, Kolkata</td>
<td>West Bengal</td>
</tr>
<tr>
<td>007</td>
<td>site Nibra Village, Hooghly</td>
<td>West Bengal</td>
</tr>
<tr>
<td>008</td>
<td>site Minu Weigh Bridge, Hooghly</td>
<td>West Bengal</td>
</tr>
<tr>
<td>009</td>
<td>site Shivang Texrium, Hooghly</td>
<td>West Bengal</td>
</tr>
<tr>
<td>010</td>
<td>site Dhapa MSW Dump site, Kolkata</td>
<td>West Bengal</td>
</tr>
<tr>
<td>011</td>
<td>site TTCWMA, Navi Mumbai</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>012</td>
<td>office STC HQ, Mumbai</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>013</td>
<td>office Technochem Agency HQ, Mumbai</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>014</td>
<td>office TNPCB HQ, Chennai</td>
<td>Tamil Nadu</td>
</tr>
<tr>
<td>015</td>
<td>site TNCCCL, Ranipet</td>
<td>Tamil Nadu</td>
</tr>
</tbody>
</table>
6 Step 1.5 – Final analysis of the Typology

6.1 Introduction
In step 1.5 a comprehensive evaluation of steps 1.1 to 1.4 was carried out, including the results of studying the Blacksmith database, which was made accessible for the project around that time. In this chapter, we present the result, the typology of contaminated sites.

Note: the Assignment 1 database was not available for the Assignment 2 project team at the time of writing of this report. The TEP confirmed this expectation during the August TEP-meeting. On the other hand it is not expected that the typology will need to be extended with additional types, as the typology is generic and robust. Nevertheless, the typology presented in this chapter will be validated once the Assignment 1 inventory, including the results of the site visits, becomes available. More on this in Section 6.6.

6.2 Theoretical backgrounds – why a typology?
Contaminated sites are delineated areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the environment. These sites often pose multi-faceted health and environmental problems. They can impact all components of the environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, industrial, rural, urban, or wilderness areas. All those elements are of importance in the designing and implementation process of those remediated sites. By developing a typology of contaminated sites these elements can be made manageable.

In this assignment we use the following definition of Typology: “The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites”. The typology can be used for multiple purposes from which some go beyond the scope of assignment 2:
- all contaminated sites can be described based on actual data;
- all contaminated sites can be classified based on policy based criteria to be developed in Assignment 3;
- all contaminated sites can be ranked and programmed in terms of priority setting based on policy based criteria to be developed in Assignment 3;
- categories of effective and economically similar remediation options, to be assessed in Task 3, can be assigned.
Basics of typology
The typology described in this report has been developed primarily to support the user of the Guidance document, to be developed in Task 4 in this assignment, in assessing soil remediation. The typology therefore should give a clear overview of all types of contaminated sites, including those where the contamination is soil, groundwater or surface water related, supporting the different steps in the process of soil remediation. If the typology is not distinctive, it will not provide the users with enough support. If the typology is too broad it will overstock the user in giving him too many details. An example of overstocking the typology is to distinguish all possible contaminants, leading to a huge bulk of types. In such a situation, only if one type of contaminant is overabundant the designation of a contamination specific type will effectively support the user.

Examples of foreign types of contaminated sites are gas distribution stations, private small scale subsurface oil storage tanks or immobile top layer contaminations in urban areas (brownfields). These specific and very detailed types are defined based on a combination of technical and non technical characteristics. The complexity of some of these types of sites is low, remediation can be dealt with in a uniform way, governmental laws are applied to enforce the remediation of the huge quantity of sites or type related subsidies are made available to speed up the remediation program.

The typology we present in this report is based on the results of Steps 1.1 through 1.4, and on the inventory of national and international approaches, carried out in task 2 in this assignment, and is made applicable for the use in Indian conditions and the scope of the NPRPS. As a result of this approach, the typology is applicable to almost any probable contaminated site. The user is guided through the typology, using the Indian hazardous waste (HW)-rules (Management, Handling and Transboundary Movement Rules, 2008). Elements of this Act which are used in the typology are Schedule I, listing processes generating hazardous wastes, and Schedule II, presenting a list of waste constituents with concentration limits.

Concluding from the inventory of international approaches as documented in the Task 2 report of Assignment 2 the typology is based on activities potentially leading to soil contamination in a specific geometry (e.g. spatial spreading), the first step in building a Conceptual Site Model. This means the typology is not primary based on a complete list of e.g. types of industries as is sometimes used in developing typologies or specific contaminants. Such an approach would lead to a very long list not giving a systematic approach for the development of site assessment strategies or remediation options. Task 2 reports that a typology for example based on a type of industry is used for programming or financing reasons and not for technical similarity. The typology is based on activities and geometry of the contamination to be used when developing a site assessment strategy. Combined with site specific information on chemical substances and soil characteristics this typology is useful to get insight in realistic remediation options to facilitate the process of remediation option appraisal.
6.3 Scope of the typology
Care has been taken to make sure that the scope of the typology includes at least the sites included on the lists mentioned below. The developed typology, described in Section 6.4, is generic and robust, so that any contaminated or potentially contaminated site identified in India can be classified within its scope. Please refer to Section 6.6 for the classification of identified sites within the typology.

The scope of the typology is based on the following sites:
- Sites present in the available lists of sites:
  - CPCB Annexure I List of hazardous waste dump sites (provided by CPCB 20120410);
  - CPCB List of hazardous waste dump sites (provided by CPCB 20120410);
  - A Compilation of contaminated places India initial site assessment reports supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program, June 2007, Blacksmith Institute;
  - Blacksmith Institute database (http://www.dbisa.org/isa/in/).
- For these types an overview of remediation options (Task 3) and remediation techniques will be presented (Task 4). Please refer to Section 6.6 for more information on the validation of the typology against the Assignment 1 database;
- Sites meeting the characteristics of waste constituents (HW-rules, Schedule II) or processes generating hazardous waste (HW-rules, Schedule I) as far as they are not covered by the types in which sites are present from the sources mentioned above. Note. Indian Hazardous Waste regulation describes Secured Landfill sites. As these sites are regarded as secure, any possible contamination emerging from these sites is covered by technical measures and procedures attached to these sites. If such measures are not sufficient and soil remediation becomes necessary the landfill sites should be regarded as a S1-c type as indicated in table 6.1;
- Site common in inventories of policies in other countries (provide by the Task 2 results).

As the Guidance document will offer a generic Remediation Option Appraisal (ROA) tool to assess the best remediation option for specific sites, all types as described by this typology can be assessed using the Guidance. This typology covers all possible contaminated sites from 'mega contaminated sites', containing over 100,000 megatons of contaminated soil, right down to very small scale sites, containing minor quantities of contaminated soil. Although for one type a series of remediation options can be given, these differences in the amount of contaminated soil can result in the selection of different remediation options. The guidance will lead the user through such elements in the process of remediation option appraisal.
6.4 Typology

Table 6.1 presents an overview of the typology, by showing all activities leading to contaminated soil and types of spreading. These activities are regardless of the party causing the contamination. E.g. liquid phase contaminations are not necessarily focused only to industrial activities. On the other hand it is expected that most of this type of contaminations can be found in industrial areas. The following main types of contaminated sites are distinguished using this approach:

**Source related:**
- Type S1: Land bound solid phase contamination;
- Type S2: Water bound sediments solid phase contamination;
- Type L: Land bound liquid phase contamination. The source of this type of contaminations is connected to human activities or infrastructure.

**Pathway related:**
- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids);
- Type P2: Groundwater contamination.

Note 1: Although elements in the typology are based on the ‘source-pathway-receptor’ approach, it is not primary ‘receptor’ (risk) based. The typology is not based on risks (risks to human health, ecological risks, spreading or vaporizing). This is because site assessment and soil remediation options appraisal, for which this typology is developed, is not limited to the assessment of unacceptable risks, but needs to give insight in a contaminated site as a whole.

Note 2: depending on a specific situation:
- a combination of these types may be found on one site. Example: a land bound storage of Chromium containing hazardous waste (type S1), leaching Chromium to groundwater and leading to a contaminated groundwater plume (type P2). This combination of types on one single site could result in multiple site assessment strategies and multiple remedial options, each assessing the different types of contaminants (both the site assessment and remediation approach can be combined for practical reasons);
- multiple sites can form a cluster of contaminated sites of a specific type or combination of types. A combination of sites of a specific type in a single cluster or a combination of types on a single site can be recognized. These situations could be indicated as a “cluster-site” with a wide variety of scales. In general, the applicability of remediation techniques will not depend on this setting, but correct balancing of remediation techniques per type of site in a cluster will lead stakeholders to the best applicable remediation option. This principle of balancing, including site scale factors, is assessed in the Guidance document and is independent of the type of sites.

Note 3: Coordination with the Assignment 1 project team has resulted in the incorporation of the typology in the Assignment 1 database.

Note 4: Both in type L as in type P1 liquid phase contaminants are involved. Type P1 is distinguished from type L by the specific type of contaminant, Non-Aqueous Phase Liquids (NAPL’s), which have a characteristic spreading pattern on or in the groundwa-
ter aquifer. This characteristic leads to different site assessment strategies, spreading mechanisms, risk profiles and remediation approaches for type P1 sites, as compared to type L sites. A type L site may, due to further spreading of the contaminant plume, develop over time into a type P1 site.

The main types listed above are based on normative characteristics, which play a role in determining the basics for remedial options. Side characteristics may do so as well, but their influence will in certain cases be restricted to the finer points (mostly technical details) in the selection of remedial options or to the planning or implementation of remedial actions. Thus subtypes come into perspective when remediation option appraisal is going into the second step of option appraisal, the detailed engineering phase. In this detailed engineering phase aspects have to be included related to contaminant specific specifications of remediation techniques, assessment of specific social aspects of the remedial actions or site use specific technical requirements.

Case example. The first step of a site specific remediation option appraisal, based on normative characteristics only, has shown that the remediation should be implemented within a period of less than two months and should result in a removal of all contaminants. In this case only then the site will meet the specific needs for planned reconstruction works. At this point it is already clear that only excavating techniques will be applicable, rendering the assessment of in situ techniques obsolete. This saves gathering and analysing detailed information on the performance of these techniques (e.g. contaminant related performance of in situ techniques) as this will not meet any purpose.

Subtypes can be distinguished based on the following secondary criteria:

- **Type S1 and L** related subtypes are defined, based on the activity causing the contamination. HW-Schedule I (listing processes generating hazardous wastes) may help to focus on possible activities. In table 6.1 these subtypes are coded ‘a’ through ‘i’ (type S) and ‘a’ through ‘d’ (type L). These subtypes are distinguished to support the site assessment.

- **Type P1** related subtypes are defined, based on the bulk density of a NAPL (non aqueous phase liquids, dense and light). In table 6.1 these subtypes are coded ‘a’ and ‘b’ (type P1). These subtypes are distinguished to support the site assessment.

- **Land use**: urban, industrial, nature, agricultural. These subtypes are designated to support the risk assessment (as receptors are land use related) and giving a direction in the selection process of remediation options.

- **Heavy metal contaminated sites**. As sites contaminated with heavy metals are overabundant in the CPCB- and Blacksmith reports, these sites will be assigned to a specific subtype.
This subtype is distinguished to support the user in the remediation option appraisal giving best practices in soil remediation options.

The typology is aimed to support the remediation options appraisal. Some examples to illustrate this point. A site assessment plan for a S1-f type contaminated site (deposition by flooding or washing) will focus on the boundaries of the flooded areas of a river system, easily recognizable on maps or areal pictures. Once the pattern of flooding is known an extensive sampling plan can be carried out to validate the flooding pattern and to validate the hypothesis on the spreading of the contamination with field data. By contrast, a site assessment plan for a S1-c type of contaminated site (storage of contaminated material) will focus on a relatively small area where human activities such as incineration have taken place.

The total volume of the removal of contaminated material, which accounts for the major part of remediation costs, will be smaller for a S1-e type of contaminated site (atmospheric deposition) than for a S1-a type (soil mixed with contaminated material). Therefore, it is more likely that the best applicable remediation option on a S1-e type site will be a complete removal of all contaminants, where for a S1-a type site a capping option is more likely to come into perspective.
<table>
<thead>
<tr>
<th>Type</th>
<th>Description or activity</th>
<th>Typical field characteristics of the site / examples</th>
<th>Icon with typical field situation (cross-section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td><strong>Solid phase contamination (land bound site)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1-a</td>
<td>Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.</td>
<td>Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S1-b</td>
<td>Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.</td>
<td>Well defined body of non-mixed contaminants. E.g. storage of tailings.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S1-c</td>
<td>(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. ‘Leftovers’ of incineration and burning of material.</td>
<td>Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S1-d</td>
<td>Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).</td>
<td>Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S1-e</td>
<td>Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.</td>
<td>Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S1-f</td>
<td>Deposition by flooding or washing.</td>
<td>Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is determined by the flooding of flow of a watersystem.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>S-2</td>
<td><strong>Solid phase contamination (water bound site)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-2</td>
<td>Contaminated open water sediments.</td>
<td>Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.</td>
<td><img src="https://example.com/icon.png" alt="Icon" /></td>
</tr>
<tr>
<td>Type</td>
<td>Description or activity</td>
<td>Typical field characteristics of the site / examples</td>
<td>Icon with typical field situation (cross-section)</td>
</tr>
<tr>
<td>------</td>
<td>------------------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>L-1</td>
<td>Liquid phase contamination*) (land bound site)</td>
<td>Liquid contamination in soil situated near a potential source of the contamination.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>L1-a</td>
<td>(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.</td>
<td>Liquid contamination in soil situated at any place at a liquids storage site.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>L1-b</td>
<td>Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).</td>
<td>Liquid contamination in soil situated at any place along a transport piping system or drains.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>L1-c</td>
<td>Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.</td>
<td>Liquid contamination in soil situated at the end of a transport piping or drain system.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
</tbody>
</table>
| L1-d | Spills or leaks of liquids. (either on surface or in rivers/lakes) 
*Note. Possibly leading to type S2 or P2.* | Liquid contamination in soil situated at the end of a transport piping or drain system. | ![Icon](image) |

*) caused by multiple sources or situation where source cannot be attributed.
### Step 1.5 – Final analysis of the Typology

<table>
<thead>
<tr>
<th>Type</th>
<th>Description or activity</th>
<th>Typical field characteristics of the site / examples</th>
<th>Icon with typical field situation (cross-section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-1</td>
<td>NAPL contaminants in soil</td>
<td>Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL’s laying of the bottom of an aquifer can result in a ‘secondary source’ of spreading of type P-2</td>
<td><img src="image1" alt="Icon" /></td>
</tr>
<tr>
<td>P1-a</td>
<td>Dense Non-Aqueous Phase Liquid (DNAPL a) ) in permeable soil. (bulk density &gt; water)</td>
<td>Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL’s laying of the bottom of an aquifer can result in a ‘secondary source’ of spreading of type P-2</td>
<td><img src="image2" alt="Icon" /></td>
</tr>
<tr>
<td>P1-b</td>
<td>Light Non-Aqueous Phase Liquid (LNAPL b) ) in permeable soil. (bulk density &lt; water)</td>
<td>Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL’s laying at the top of a water table can result in a ‘secondary source’ of spreading of type P-2</td>
<td><img src="image3" alt="Icon" /></td>
</tr>
<tr>
<td>P-2</td>
<td>Leached or dissolved contaminants in groundwater</td>
<td>Due to spreading of leachate or mobile dissolved contaminants in a permeable soil</td>
<td><img src="image4" alt="Icon" /></td>
</tr>
<tr>
<td>P-2</td>
<td>Groundwater contamination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notes

** Sites present in the available lists of sites (CPCB, Blacksmith-list, Blacksmith database)

* Sites meeting the characteristics of waste constituents (HW-rules, Schedule II) or processes generating hazardous waste (HW-rules, Schedule I) or additional sites from inventories of policies in other countries (task 2)

a) A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration...
into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.

b) Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.

**Table 6.2 Key to icons in table 6.1**

<table>
<thead>
<tr>
<th>Icon</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Solid waste or solid waste mixed with soil" /></td>
<td>Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.</td>
</tr>
<tr>
<td><img src="image" alt="Groundwater table" /></td>
<td>Groundwater table</td>
</tr>
<tr>
<td><img src="image" alt="Base of aquifer / top of impermeable layer" /></td>
<td>Base of aquifer / top of impermeable layer.</td>
</tr>
<tr>
<td><img src="image" alt="Liquid waste. Pure or mixed with soil." /></td>
<td>Liquid waste. Pure or mixed with soil.</td>
</tr>
<tr>
<td><img src="image" alt="Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil." /></td>
<td>Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.</td>
</tr>
<tr>
<td><img src="image" alt="Contaminated groundwater plume. Depending on permeability of the soil." /></td>
<td>Contaminated groundwater plume. Depending on permeability of the soil.</td>
</tr>
<tr>
<td><img src="image" alt="DNALP or LNAPL." /></td>
<td>DNAPL or LNAPL.</td>
</tr>
<tr>
<td><img src="image" alt="Spill / leakage." /></td>
<td>Spill / leakage.</td>
</tr>
<tr>
<td><img src="image" alt="Not soil related human activity / construction e.g. industrial process, storage, bulk transfer." /></td>
<td>Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.</td>
</tr>
</tbody>
</table>
6.5 Data needed to designate sites to a specific type

The remediation options to be developed in Task 3, as well as the Guidance Document to be developed in Task 4, will be geared to types of sites in the typology. Any user of the Guidance Document will therefore, as one of the first actions in relation to a newly identified contaminated site, need to designate that site to one or more of the types in the typology. Table 6.3 shows the data needed to be able to do that.

The Guidance document, to be developed in Task 4, will offer type specific site assessment strategies to deal with additional data needed to take further steps in the option appraisal process. Aspects like detailed site investigation, sampling strategies, conceptual site models and site modelling will be described.

Table 6.3 Data needed to designate sites to a specific type

<table>
<thead>
<tr>
<th>Type of data</th>
<th>Possible data sources</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity potentially leading to soil contamination</td>
<td>Historical survey of the site. Permits and technical drawings of the industrial processes on the site. Archive of the party / parties active on the site Interviews. Site visit.</td>
<td>The site permit details the Products/Class of Products Manufactured and the type and scale of industry. HW-Schedule I (listing processes generating hazardous wastes) can be used as checklist. Please see the separate attachment of Type Industry that can be identified from the Permit.</td>
</tr>
<tr>
<td>Time span of the activity</td>
<td>Historical survey of the site Permits and technical drawings of the industrial processes on the site Archive of the party / parties active on the site Interviews. Site visit.</td>
<td>Use HW-Schedule I (listing processes generating hazardous wastes) as a checklist and HW-Schedule II, giving a list of waste constituents. This list of waste constituents is elaborate and applicable to nearly all the industrial processes.</td>
</tr>
<tr>
<td>Contaminants used on the site</td>
<td>Historical survey of the site Permits and technical drawings of the industrial processes on the site Archive of the party / parties active on the site Interviews. Site visit.</td>
<td>Use HW-Schedule I (listing processes generating hazardous wastes) as a checklist and HW-Schedule II, giving a list of waste constituents. This list of waste constituents is elaborate and applicable to nearly all the industrial processes.</td>
</tr>
<tr>
<td>Terrain conditions prior to the activity</td>
<td>Historical survey of the site using areal pictures Site visit Geomorphologic data Maps available at the collector’s office of the region.</td>
<td>e.g. presence of pits, ditches, depressions</td>
</tr>
<tr>
<td>Geology and hydrology of the site</td>
<td>Central Soil and Material Research Station (CSMRS) of Ministry of Water Resources, Govt. of India (database on soils in India)</td>
<td>e.g. soil layering, permeability, organic and clay compounds in soil, aquifers and groundwater characteristics</td>
</tr>
<tr>
<td>Physical properties of contaminants</td>
<td>As above</td>
<td>e.g. phase (solid, aqueous), solubility, density, co-contaminants, spreading characteristics in soil and groundwater</td>
</tr>
<tr>
<td>Presence of adequate protective measures to prevent soil contamination</td>
<td>Permits and technical drawings of the industrial premises. Archive of the party / parties active on the site Interviews. Site visit.</td>
<td></td>
</tr>
<tr>
<td>Type of data</td>
<td>Possible data sources</td>
<td>Comments</td>
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<td>-------------</td>
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</tr>
<tr>
<td>Land use</td>
<td>Location of the site. State Industrial Development Corporations. SPCBs. PCCs.</td>
<td>e.g. urban, industrial, nature, agricultural; source and pathway may have different types of land use</td>
</tr>
</tbody>
</table>

*) As per Sr.No.70.12.(12) RE:Location of Industrial Sites and Secured Landfill: of the Supreme Court Order dated 14th October 2003, only industries in those States where the Hazardous Waste generation is less than 20,000MT per year, are allowed to temporarily store Hazardous Waste on the premises before they get a permission for Transboundary Movement. In all other States where the Hazardous Waste generation is more than 20,000MT per year, Industry can store Hazardous Waste on the premises not more than 90 days but is required to transfer the waste to Common Hazardous Waste Treatment Storage Facility (CHWTSDF) in that State. Not all permits specify on-site Hazardous Waste Storage with adequate protection. In earlier time, say 10 years before Industries have illegally stored Hazardous Wastes on the premises without due protection.

### 6.6 Validation of the typology

**Preliminary validation**

The typology has been applied to the sites included in the available lists of sites, i.e. the CPCB-list, the Blacksmith Institute list and the Blacksmith Institute database. Table 6.4 presents the results of this application. Distinctive elements to designate contaminated sites to a specific type or specific types are the processes leading to the contamination, such as emplacement of contaminated materials, mixing of contaminants with soil, embankment of low situated sites with contaminant material or the leakages or spill of liquid material transport pipes.

Table 6.4 clearly shows that all main site types have been identified in India except for type P1, which could not be recognized due to lack of very specific data. From table 6.4 it is also concluded that all sites listed in the three sources used can be classified using the typology.

The purpose of table 6.4 is to provide an overview of all types and subtypes in the developed typology. We have supported this by including the names of some sites as examples to every type. The reason not all sites from the CPCB list, Blacksmith Institute list, and Blacksmith Institute database are mentioned in this table is that the purpose of the table is not to give a ranking of all assessed sites.

For a number of sites the CPCB list, the Blacksmith Institute list and the Blacksmith Institute database show limited data. Many sites are still under review or under investigation or have not been investigated in detail. Therefore, details on the analysis of these data as reported in table 6.4 may be under dispute. This would definitely have been the case should subtypes have been used in table 6.4. On the other hand, this application of the typology to these sites has clearly shown the working methodology used is robust and the results will be useful for the NPRPS.
Validation against database from Inventory project

It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. We have done a tentative validation against a draft version of this database, made available to us by the project team of assignment 1 on 13th December 2012. This tentative validation made clear that all sites in this version of the database, except the sites where contamination is limited to surface water, could be assigned to a type within the typology. In some cases multiple types are assigned to a site. The structure of the typology allows this multiple assignment. We will include the results of the validation against the final version of the database in the final report of this project, to be developed in Task 6. In case the validation results in the need to apply changes to the results of Task 3 (Review of remediation options) and Task 4 (Guidance document), these will be dealt with in detail in the same final report.
Table 6.4  Overview of (combination of) types of sites applicable to the CPCB-list, the Blacksmith Institute list, and the Blacksmith Institute database

<table>
<thead>
<tr>
<th>Type</th>
<th>Subtype</th>
<th>Example sites assigned to a type of site (including reference to list where site is included)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>S2</td>
<td>Land use (present) Nature Agriculture / rural Nature of contaminants</td>
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<td></td>
<td>L</td>
<td>Urban Industry Nature</td>
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<td></td>
<td>P1</td>
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<td>P2</td>
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</tbody>
</table>

(x) subtype ‘e’ only
* as per request by the TEP company names have been deleted from the site names

Source of site data:
(1) CPCB Annexure I List of hazardous waste dump sites (procured by CPCB 20120410) or CPCB List of hazardous waste dump sites (procured by CPCB 20120410).
(2) A Compilation of contaminated places India initial site assessment reports supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program, June 200, Blacksmith Institute.
(3) Blacksmith Institute database (http://www.dbisa.org/isa/in/).
6.7 Analysis of the developed typology

The typology presented in this report has been based on data from sources mentioned in chapter 2, and the Blacksmith Institute database. To mitigate the effects of the possibility of not covering all sites in India, the typology has also been based on the Task 2 report and on our expertise on contaminated sites outside India, as per the discussion on this point with the Technical Expert Panel. Using this approach the typology is fit for sites not yet incorporated in the sources used.

Note: not all sites from the CPCB list, Blacksmith Institute list and Blacksmith Institute database could be assigned to a type due to poor data.

Figure 6.1 demonstrates the number of sites with a specific key pollutant. This figure is based on the Blacksmith Institute database. This database encloses a large number of sites (400+) and has an overlap with the sites from the CPCB-list and the Blacksmith Institute report (2007). Therefore, figure 6.1 presents a solid focus for the Guidance document. In case a specific (group) of contamination(s) is common in India the Guidance document will present specific additional backgrounds, e.g. the evaluation of remediation techniques for assessing hexavalent chromium.

Figure 6.1 Number of sites with specific key pollutants

From this graph it can be concluded that heavy metals (in soil, groundwater or surface water) are the most common type of contaminant identified in India. Combined with detailed information from the sites it can be concluded that most sites are not contaminated with just a single key pollutant, but rather with a mix including other pollutants.
6.8 Using the typology within the NPRPS framework

The typology described in this report will form the basis for Task 3, where potential remediation options will be developed for each type of site, incorporating best practices from other countries. During this step, contaminant specific aspects of techniques will come into view. An analysis of these remediation options will offer insight in the best applicable techniques. This will support the user of the Guidance document, to be developed in Task 4, in the remediation options appraisal process. It will be the Guidance document that will take the user through the generic process of remediation option appraisal. Detailed site characteristics such as those listed below will be dealt with:

- **physical aspects, relevant for the technical aspects of remediation:**
  - chemical content and origin of the waste sites. Example: from the site data available at this time it is evident that many sites are contaminated with hexavalent chromium sludge. This type of site should fit into the typology and the Task 3 Review will include additional backgrounds, specifically aimed at hexavalent chromium techniques;
  - size, geographical setting (natural hazards, infrastructure, distance to assets), geohydrological and geological setting. For example, the geographical setting often forms a dominant factor in the pathway of contaminants and thereby in the types of risks and applicable remediation options;
  - practical aspects of available techniques. For example, the excavation of contaminated sites and storage in a sanitary landfill (SLF) is only possible if the storage capacity is sufficient and the SLF-technology is well implemented.

- **potential and existing risks relevant for the focus of the site remediation measures (prevent human contact, prevent spreading due to land use, prevent spreading of contaminants in groundwater);**

- **practical aspects of remediation, relevant for the impact of the technical measures of remediation and a potential change in land use, both of the site itself and of the surrounding area:**
  - social context and urban setting influences the level of acceptable nuisance during the implementation of remediation options;
  - the legal and financial position of the owner and his choice to redevelop a contaminated site to a higher standard of land use is likely to influence the level of remediation;
  - urban redevelopment plans, including their planning, are likely to influence the time available for remediation and thus might exclude certain remediation techniques;
  - legal and economic aspects (ownership, political attention, liability).
Annexures
7.1 Annexure 1 Definition of a contaminated site

This annexure presents the revised version of the definition of a contaminated site, as presented by MoEF to the Assignment 1 project team in January 2013.

1(a). Definition of a contaminated site

"Contaminated Sites are delineated areas in which the constituents and characteristics of the toxic and hazardous substances, caused by humans, exist at levels and in conditions which pose existing or imminent threats to human health and/or the environment”.

Notes:

I. Site is defined by the area consisting of the aggregation of sources, the areas between sources, and areas that may have been contaminated due to migration from sources; although contaminated groundwater plumes normally not will be considered as a part of the site boundary. Site boundaries are independent of property boundaries.

II Confirmed presence of toxic and hazardous substances having constituents and characteristics of the contaminants as per the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 (see Appendix D).

III. Natural contaminants are not treated as contaminants or substances, which basically are anthropogenic.

IV. Land would not be considered contaminated merely due to presence of hazardous substances in, on or under the land. The level of contaminants should be above risk level. Land may be contaminated even if it was contaminated partly or entirely by the migration of contaminants into, onto or under the land from other land.

V. The risk may be considered based on human health and/or the environment; and may be accessed on the basis of existing or planned future land use as well as use of ground water and surface water.

VI. The risk approach should also take into account any possible combination of contaminants [interaction between contaminants and or with environmental constituents] or certain levels of contaminants, wherever applicable

1(b). Definition of a probably contaminated site

"Sites with alleged (apparent, purported) but not scientifically proven presence of constituents of contaminants or substances caused by humans at concentrations and characteristics which can either pose a significant risk to human health or the environment with regard to present or future land use plan [pattern] or exceeding specific concentrations or standards prescribed for human health and or the envi-
Notes:

I. The constituents and characteristics of contaminants shall be as per Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.

II. Natural contaminants are not treated as contaminants or substances, which basically are anthropogenic.

III. The risk may be considered based on human health and/or the environment; and may be assessed on the basis of present or planned future land use as well as use of ground water and surface water.

IV. The risk approach should also take into account any possible combination of contaminants [interaction between contaminants and or with environmental constituents] or certain levels of contaminants, wherever applicable.
### 7.2 Annexure 2 Site related data provided or approved by the Client

<table>
<thead>
<tr>
<th>nr</th>
<th>title document</th>
<th>content document</th>
<th>organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No title, Chapter - 1</td>
<td>summary of 12 priorities of contaminated dump sites</td>
<td>CPCB</td>
</tr>
<tr>
<td>2</td>
<td>No title, Annexure</td>
<td>For each of the States a description of the hazardous waste dump sites</td>
<td>CPCB</td>
</tr>
<tr>
<td>3</td>
<td>No title, Annexure - I</td>
<td>List of hazardous waste contaminated dump sites in the country (preliminary information)</td>
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</tr>
<tr>
<td>4</td>
<td>No title</td>
<td>Table/list with contaminated sites; almost same information as nr. 3</td>
<td>CPCB</td>
</tr>
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<td>Dump Sites Orissa - GTZ report</td>
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<td>Initial Site Assessment Report POLLUTED PLACES - India</td>
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<td>Investigation and Remediation Plan</td>
<td>SENES</td>
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<td>West Bengal_Rem Plan</td>
<td>Investigation and Remediation Plan</td>
<td>SENES</td>
</tr>
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<td>29</td>
<td>Need Assessment for Implementation of Hazardous Waste Management &amp; Preparation of NPRPS</td>
<td></td>
<td>SENES</td>
</tr>
<tr>
<td>30</td>
<td>Blacksmith database (internet access)</td>
<td>400+ site factsheets</td>
<td>Blacksmith Institute</td>
</tr>
</tbody>
</table>
7.3 Annexure 3 Site visit reports
METHODOLOGIES FOR NPRPS INDIA

Site Appreciation Report - Visit to APPCB and Noor Mohammed Kunta - 11 January 2012

A first hand feel for the available data:

In response to our request during the pre-bid meeting on 10th January 2012, the Project Director [CBIPMP] has kindly arranged for Ms. Ramani at the Andhra Pradesh Pollution Control Board [APPCB] to receive two representatives of the consortium on 11th January 2012. Our discussion with Ms. Ramani and some of her colleagues enabled us to get a first hand feel for site conditions and to make a first assessment of the structure, nature, format, and quantum of the available data and of the software used. A visit to Noor Mohammed Kunta in Hyderabad gave us an overall impression of this pilot site.

Action taken on orphan sites:

We learned from Ms. Ramani and Mr. Bhaskar that both Andhra Pradesh and Maharashtra have declared NIL orphan contaminated sites. AP was the first state to adopt Secure Landfilling. APPCB acquired an existing contaminated site at Dundigul in Ranga Reddy District, treated the same and is now using this site, named TSDF, to receive and treat contaminated material from various orphan and owned contaminated sites. Environment Protection Training and Research Institute (EPTRI) identified all the orphan contaminated sites in AP. Based on this report, APPCB spent Rs 19 million in collecting, transporting and treating the contaminated soils from individual sites to the TSDF. In total, 24,000 tons of contaminated material was transported from 147 orphan sites (in 44 locations) to the TSDF. Arrangements with a few cement factories for co-incineration of the contaminated waste at reasonable cost has encouraged the industries to responsibly handle their contaminated wastes.

Plans for the future:

- an Environmental Compliance Assistance Center [ECAC] is expected to be operational by June 2012;
- AP does not currently operate a site ranking system of its own;
- on the basis of a national policy, AP will decide whether additional State policy is needed to account for specific regional circumstances.

Current Remediation Works:

As mentioned in the Project Appraisal Document [PAD], Andhra Pradesh currently has undertaken remediation works for two sites: Noor Mohammed Kunta and Kadapa. A visit to Noor Mohammed Kunta and the adjacent waste water treatment facility gave us an impression of the site and the surroundings. The pond, in suburban Hyderabad, is between a mix of small industries/businesses and residential dwellings, and a railroad, upstream, and the Agricultural University Campus, and a trunk road, downstream. The pond and its sludge have been contaminated mainly by dyes from the textile industries for Katedan Industrial Zone. The regulator has closed down these industries/businesses, and the pond’s sludge is currently being characterized, in which APPCB samplers take part. On the basis of the results, remedial action is envisaged, and the regulator will ensure compliance by remaining industries/businesses.
GIS - A substantial initiative by APPCB:

APPCB seems to have taken a substantial initiative in developing a GIS facility. A discussion with Ms. Sudha and Mr. Padmanabhan gave us a first understanding of their system. The GIS and layering was originally, in 2002-2005, based on guidelines provided by the CPCB to each SPCB, and is due for an update. APPCB GIS cell used 1:50,000 scale topographic sheets of the Survey of India, scanned them and digitized the raster images using ERADS. They use ARC GIS version 9 – although they are looking to upgrade the same to ARC GIS Version 10, since this allows image processing and geo rectification. The system is visible in the field, as APPCB uses this GIS in deciding whether or not it should grant permission for the setting up of industries in certain zones.
METHODOLOGIES FOR NPRPS INDIA

Meeting report visits CETP Delhi Inception phase, 11 April 2012

Date meeting: April 11th 2012
Purpose meeting: site visits possible contaminated sites
Location Meeting: two sites for treatment waste water, Wazirpur Industrial Pollution Control CETP Society and Badli Industrial Estate CETP Society, Delhi
Present: Mrs. Nupur, (in-charge & Chemist- Wazirpur CETP), O. P. Bhowal, Executive Secretary CETP, Ravi Sood, General Secretary, Badli CETP, Mr. Chawla (senior environmental engineer DPCB), Mr. Surindar Singh (environmental engineer DPCC), project team members: Mr. H. Rane, Dr. S. Sen, Mr. F. Vliegenthart, Mr. R. Heijer, Mr. P. Oude Boerrigter

Introduction
The project team for the Methodologies project had the opportunity to visit Delhi Pollution Control Committee. Member Secretary Mr. Sandeep Mishra invited the project team for a short discussion on soil contamination and waste management. Mr. Mishra and members of his team emphasized the problems with waste management due to lack of space for final disposal sites. There were some discussions on the Dutch approach and experiences.

This visit was the starting point for two site visits of CETP-sites, the project team could visit accompanied by DPCC-employees.

Information CETP employees
- The project team visited two sites where waste water of industrial sites is treated. One site was built in about 2000, the other site is 6 years old.
- The CETP construction is funded, 25% by MoEF, 20% by DIDC (Delhi Industrial Development Corporation), 5% by DPCC and 50% by member group of industrial companies. Fees are collected by DIDC for the amount of water that each industry is consuming irrespective of discharge of effluent.
- CETP receives waste water from many industries, mainly metal constructing industries.
- Transport of waste water is by subsurface sewers, sometimes 2-3 meters below surface.
- Sludge generated at the waste water treatment plant is dewatered by filters.
- Effluent of the facility is discharged to the river / surface water.
- The last step at the site is storage of sludge in tanks. There are no liners in the sludge tanks, the roofs will not always be water tight.
- DPCC task is to check the quality of the discharged water of CETP sites. There is no check on the quality of the sludge because that is too expensive.
- There is no possibility to transport the sludge to a final deposition site for hazardous waste. At CETP-sites the storage tanks are filled with dry sludge. This sludge contains chemical elements like heavy metals and POP.
- The acidity of the waste water when entering the CETP-facility, is 3,5 PH and DOC (termed as COD- Chemical Oxygen Demand) is 45 mg/L. To reduce acidity lime is added. To reduce DOC to 20-25 m/L, the wastewater is aerated.
- Soil or groundwater quality is not tested near these sites. Groundwater depth is 8 feet below surface.

Information of Mr. Rane:
- CETP-facilities have an environmental permit;
- When not complying regulations, a fine can be given and sometimes a bank guarantee is required
- Permits can be withdrawn as ultimate penalty.

Internal conclusion project team:
These two facilities are facing problems functioning; sludge cannot be transported to a final disposal dump site for hazardous waste.

The storage tanks are filled with old sludge. No ‘fresh’ sludge was seen. We presume that all waste water is only treated to raise pH-level before discharging to rivers / surface waters.

At these sites many tons of hazardous waste is stored, without good soil protection measures.

The sewage systems that are transporting discharged water from industrial companies to CETP facilities can possibly leak, causing groundwater contamination outside the borders of industries or CETP sites.

<table>
<thead>
<tr>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name / location</td>
<td>Wazirpur</td>
</tr>
<tr>
<td>Number of industries, waste water is collected from</td>
<td>4,000</td>
</tr>
<tr>
<td>Year start of facility</td>
<td>About 2000</td>
</tr>
<tr>
<td>Amount of waste water collected</td>
<td>24,000 m³/day maximum capacity; only 4 % is presently used capacity</td>
</tr>
<tr>
<td>pH of collected waste water</td>
<td>3.5</td>
</tr>
<tr>
<td>Number of sludge tanks</td>
<td>8, capacity of one tank was 25x15x3 m³.</td>
</tr>
<tr>
<td>Sludge generation</td>
<td>1000 to 2000kg/day</td>
</tr>
</tbody>
</table>
METHODOLOGIES FOR NPRPS INDIA

Meeting report TTC Waste Management Association, 13 April 2012

TTC Waste Management Association
Mr. P.M. Sreevalsan, Site Manager
Dr. N.R. Nimskar
Several colleagues TTCWMA

Projectteam:
Mr. A. de Groof Grontmij, Netherlands
Mr. R. Jambagi Indus Technologies
Mr. R. Heijer Grontmij, Netherlands
Mr. P. Oude Boerrigter Grontmij, Netherlands
Mr. F. Vliegenthart Grontmij, Netherlands
Mr. H. Rane Technochem, Mumbai
Mrs. Dr. S. Sen STC, Mumbai

Review Points:

A. Owners;
B. Disposal site;
C. Type of waste;
D. Efficiency waste management and other environmental aspects

Observations, Comments and Suggestions on the above Review Points:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Observation</th>
<th>Comments / Suggestion</th>
</tr>
</thead>
</table>
| A.     | Owners      | Industries are the owner of the TTCWMA, which is a company funded by an association of 1,650 companies (almost all companies in the region);
|        |             | In board of directors representatives of BASF, SIEMENS are present amongst others;
|        |             | TTCWMA reports environmental results to Maharashtra-PCB (MPCB);
|        |             | Financial support for construction of site was (Capital Investment) : MoEF 25%, MIDC 20%, MPCB 5% (total 50% of Capital Cost) and member industries contributed the rest 50%.
|        |             | Within the borders of TTCWMA-site a secure landfill site of hazardous waste is present;
|        |             | In others States these facilities are there as well, but nowhere there is an industry association constructed and operated site that runs this like here. All other facilities are privately owned. |
| B.     | Disposal site | The landfill was built in 2009 by Indian contractors;
|        |             | It can contain 300,000 Metric Tons of waste over 10 years period;
|        |             | The soil protection measures are: sealing of the waste by under laying and upper laying HDPE and mineral layers;
<p>|        |             | The site has a surface of 7,000 m2; |</p>
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Observation</th>
<th>Comments / Suggestion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater level is 45 m below surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper layers of soil have thickness of couple of meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under lying Bedrock consists of basalt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater is not used for drinking or process water. Only a small amount is pumped up for using as irrigation water for the gardens of the site.</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Type of waste</td>
<td>After 3 years the capacity is used. Last year one company provided 100,000 Metric tons of waste, due to a soil remediation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The waste is transported from industries to site by truck;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>During monsoon period the waste is not stored in the landfill site but will be kept at the production sites of the industries. TTCWMA has some space for storing waste before final disposal can take place. Sludge material will not be accepted and will be sent back to the companies if not meeting the pre-estimated specifications;</td>
</tr>
<tr>
<td>D.</td>
<td>Efficiency waste management and other environmental aspects</td>
<td>Regulations on waste say that waste with higher caloric value than 2,500 cal/kg must be incinerated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A cement industry can use certain waste as fuel. This can be an efficient way to save primary fuel, but due to regulations on segregation of waste, this is not an option. Of course this is not the primary scope of this Methodologies project but there is some overlay in practical situations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Another situation that is related to our project is the waste management of about 5,000 small units of industry. This is not regarded as hazardous waste due to the small amount. The waste is treated as municipal waste and relatively high costs are made.</td>
</tr>
</tbody>
</table>
METHODOLOGIES FOR NPRPS INDIA

Background and Draft Report of the visit of Dutch/Indian consortium to Tamil Nadu PCB and site visit to Ranipet

Monday-Tuesday, 25th and 26th June 2012

Present

Mr. R. Kumar, Joint Chief Engineer, TNPCB, Chennai
Mr. Sumargopan, TNPCB, Chennai
Mr. Er. P. Kamraj, District Environmental Engineer, Vellore, TNPCB & Others
Mr. A. de Groof, Grontmij, Netherlands
Mr. R. Jambage, Indus Technologies (only 25th)
Mr. R. Heijer, Grontmij, Netherlands
Mr. P. Oude Boerrigter, Grontmij, Netherlands
Mr. H. Rane, Technochem, Mumbai
Mr. D. Deshpande, Technochem, Mumbai
Mr. R. Sridhar, STC, Chennai
Mr. D. Pari, STC, Chennai

Background for the visit and objectives

The Ministry of Environment and Forests is carrying out the World Bank financed CBIPMP. Towards the end of March 2012, MoEF has, within the framework of this project, commissioned three studies, aimed at developing a basis for a National Programme for the Remediation of Polluted Sites (NPRPS) in India. While Study 1 should deliver an inventory of contaminated sites across India, Study 3 should deliver key elements for the NPRPS itself. A consortium of Grontmij, STC and Technochem, together with Indus Technologies from The Netherlands, is carrying out Study 2, aimed at developing methodologies for rehabilitation of the contaminated/probably sites. From the moment a contaminated site has been identified, a series of decisions on required action will need to be taken. The outcome of these decisions largely depend on the type of site. The consortium is planning to develop a set of tools, most important of which will be a Guidance Document that should guide CPCB and SPCB’s through every one of these decisions. These documents, it is expected, will be used by CPCB, SPCB and other implementing agencies in India for rehabilitation of sites at present and in future.

A key part of the work of Dutch-Indian consortium is discussion of selected, representative SPCBs and visit to representative sites. This exercise is aimed at getting an understanding of ground level conditions in India, assess the nature and extent of technical and non-technical expertise available with SPCBs and understand the current practices relating to remediation of contaminated sites.

The discussions with respective SPCBs and information gathered during site visits will be used by the consortium to:

a. Identify and recommend further capability building requirements of visited SPCBs and sites, their technological and non-technical needs, training requirements and other inputs needed to strengthen the implementation agencies' capabilities to undertake rehabilitation work of contaminated sites

b. Assess the criticality of rehabilitation work needed at the visited and similar sites and report the same to MOEF/WB as a part of final reports
c. Improve the tools, standards, methods and other aids being developed by the consortium to make them more user friendly for the implementing such as SPCB

The visit to TNPCB and Ranipet site was requested by the Dutch/Indian consortium after a careful study of available information at MOEF and other sources as the consortium felt that TNPCB represents a progressive and dynamic implementing agency for rehabilitation of contaminated sites and Ranipet is a representative site for application of international standards, rehabilitation methods and technologies and additional capacity building for rehabilitation and reclamation of contaminated sites. Consultation with MOEF officials confirmed our choice.

The request was made via MOEF to MS TNPCB (Dr. Balaji) and ACE (Mr.Kumar) who kindly consented to the request. Since Dr.Balaji was travelling at the time of the visit, Mr.Kumar received the delegation and facilitated the visit.

Programme of the visit, discussions and site visit

In the afternoon of Monday 25th June the project team met Mr. R. Kumar, Mr. Sumargopan and colleagues at Head Office TNPCB in Chennai. The project team learned about the organization and tasks of TNPCB through a very detailed and comprehensive presentation by Mr. R. Kumar. This provided good insight into the priorities in environmental issues for TNPCB as well as their capacity regarding hazardous waste management. The approach of soil remediation is at present being attended to by a team of three employees.

After this the project team gave a presentation on the approach of soil remediation and the best practices in selected countries. The project team and the attending TNPCB staff then discussed some options that could be of applied for the Ranipet site. It was clarified by the consortium that while designing solutions for specific sites is not within the project team’s present assignment, the consortium was happy to share information and advice on technologies and practices available in the Netherlands and other European countries on approach to remediation of sites such as Ranipet.

The project team’s representatives were taken on a guided tour over the Tamil Nadu Chromates & Chemicals Ltd. Ranipet site’s premises by Mr. R. Kumar and his staff. During this tour, on Tuesday 26th, the representatives were briefed on the site’s history of Chromium ore processing from 1976 to 2001, with a focus on the pollution’s causes due to accumulation of 1,60,000 MT of hexavalent Chromium bearing Process Residue (Sludge), the present situation, and the existing plans for taking on the contamination by removing sludge and transferring the same to a nearby contained site.

Both the site’s installations, now defunct, and the area outside the buildings, were included in the tour, as was an installation for a pilot remediation study on the premises, and several points where contaminated leachate is surfacing, both right outside the premises and a kilometre or so downstream. Additional questions on the site’s history were be asked to Mr. V. Nirmal Gandhi, the Deputy General Manager- E.H.S. at neighbouring Thirumalai Chemical Ltd. (TCL), who has personally witnessed developments over the past two decades. The group then concluded the visit by discussions over lunch.

The representatives gained insight in the intended results of the study the consortium is carrying out and the methods to achieve those results. The project team’s representatives gained insight in the TNPCB’s mandate and scope of work, relevant for the study, which is important considering they are the intended end users of the tools being developed in the study. On top of that, the consortium gained considerable insight in one of the types of contaminated sites that are subject of the study, as well as in the solutions that are being considered at present.
**Assessment, conclusion and future steps**

The Dutch consortium is very grateful to TNPCB and Mr. Kumar for the open and very informative discussions at TNPCB and during the site visit.

It is the assessment of the consortium that TNPCB’s objectives and approaches are forward looking and targets quite ambitious. TNPCB has some excellent and unique practices such as real time reporting and monitoring of some sites. They have an extensive network of district level organisations. Their current technological knowledge is significant and substantial.

However it is recognised by the consortium that rehabilitation of contaminates sites in TN, as in rest of India, is an enormous challenge and while agencies such as TNPCB are doing their best to attend to this need, their current technological and organisational capacity needs to be vastly enhanced and strengthened. They will need additional tools and training in their projects and hands on training and experience in their application.

They also need appropriate funding to undertake rehabilitation work, monitor the rehabilitated sites and take preventive measures to prevent further contamination and propagation of hazards.

These conclusions will be incorporated by the consortium in their reports and guidance documents and other deliverables to MOEF and WB.

The consortium will continue to interact with TNPCB in the next steps in its work such as exposure of the guidance documents to representative implementing agencies, training and capacity building.

The consortium would like to express its gratitude to MS TNPCB and Mr. Kumar for their assistance and cooperation and looks forward more such interaction.
The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in this report as soon as it is received.

METHODOLOGIES FOR NPRPS INDIA

Summary of site visits Kolkata West Bengal and meetings with WBPCB

Setting:
The Ministry of Environment and Forests is carrying out the World Bank financed CBIPMP. Towards the end of March 2012, MoEF has, within the framework of this project, commissioned three studies, aimed at developing a basis for a National Programme for the Remediation of Polluted Sites (NPRPS) in India. While Study 1 should deliver an inventory of polluted sites across India, Study 3 should deliver key elements for the NPRPS itself. A consortium of Grontmij, STC and Technochem, together with Indus Technologies from The Netherlands, is carrying out Study 2, aimed at developing methodologies for approaching contaminated sites. From the moment a contaminated site has been identified, a series of decisions on required action will need to be taken. The outcome of these decisions largely depends on the type of site. The consortium is planning to deliver a set of tools, most important of which will be a Guidance Document that should guide CPCB and SPCB’s through every one of these decisions.

The consortium has started the project by developing drafts of the intended tools, based on the relatively limited data that are presently available. After consultation with the Client the consortium intends to finalize the tools, based on the more comprehensive data that Study 1 will yield. The visit to WBPCB was aimed at getting an idea of the challenges a SPCB is facing in dealing with polluted sites. Paripet and Hoogli are sites listed in central databases. The visit to these sites was aimed at getting an idea of this type of listed site, to enable the consortium to develop tools more accurately aimed at this type of site.

Program:
Wednesday, 27 June 2012 – Interview with Mrs. Kundu, environmental engineer of WBPCB, at MoEF office Delhi.
Monday, 2nd July 2012 – Site visit to Nibra and Hoogli, accompanied by Mrs. Kundu.
Tuesday, 3rd July 2012 – Site Visit to Dhapa, accompanied by Mr. Bhamik of WBPCB and meeting with Prof. B. Dutta, Chairman of WBPCB and other WBPCB officials working on the project.

Members of project team, visiting Kolkata:
Mrs. Dr. S. Sen STC, Kolkata
Mr. R. Heijer Grontmij, The Netherlands
Mr. P. Oude Boerger Grontmij, The Netherlands
Mr. H. Raina Technochem, Mumbai
Mr. D. Deshpande Technochem, Mumbai

Results:
The project team gained insight in the specific situation of the three contaminated sites. With WBPCB the project team discussed on possibilities for remediation. Based on further analysis the project team will work on the Guidance document in next months.

The results of the meeting of July 3rd and the site visits have been reported in separate documents.

Apart from these documents the following points were discussed with Mrs. Kundu:
- Legal Aspects
  There is presently no mechanism to prevent construction at possibly contaminated sites like closed industrial sites. In case any application is received by the Board seeking clearance for construction of residential buildings on a known contaminated land, the WBPCB advises the builder/promoter to get the site assessed prior to construction.
- The project site at Hoogli is covered by both public and private properties making a comprehensive remediation assessment difficult when the role of the private property owners is not defined and their cooperation cannot be ensured.
- Capacity WBPCB
  - The infrastructure is highly inadequate with only four staff members working on all Waste Management issues (hazardous, bio-medical, municipal, plastic and e-waste management all
aspects including technical, legal, policy and awareness generation).
- As no comprehensive guidance is present, all activities are carried out on the basis of personal insights.

- **Scope of Methodology goals according to WBPCB**
  - Both for WBPCB and consultants / contractors
  - Assessment of remediation goals (level of risk reduction required) – future land use at the contaminated site, distance from receptors, potential of new pathways being created, etc.
  - Functional remediation options would meet local needs as long as it is backed up by a remediation policy.
  - What party is commissioned to choose the remediation option to be implemented? [assignment 3]
  - Integrated remediation approach for multiple equivalent sites with same contaminant.
  - The Guidance document should provide a method for ‘getting sites off the list’ i.e., de-contamination of contaminated sites and a tool / selection criteria for choosing site-specific remediation approach (remediation technology + communication strategy + social impact management)
  - Not to focus on only Cr remediation techniques but remediation techniques for a broader range of contaminants and taking into considerations local conditions (climate may have a role in the performance of various technologies especially those based on microbes).
  - The proposed focus of the Methodology meets the ideas of WBPCB

- **Social**
  - For land owner/ users, the value of properties is most often dominant over health issues (due to non-availability of land with same locational advantages). Thus it might be difficult to justify remediation needs where health effects are not pronounced (immediate and severe). As remediation is dealing with health issues, in discussions with land users different issues are getting mixed up and gives a bias on the focus of remediation options. Rag pickers are deprived from their income due to a clean capping layer, there will be no support for such a remediation option.
  - Only if a complete solution is given (livelihood) a remediation option is likely to be executed.

- **Sustainability issues** regular maintenance and environmental monitoring of remediated land.

- **Three following steps are important when approaching soil contamination:** 1) environmental priority; 2) social aspects in what way assessment and remediation are applicable? 3) choosing methodology.

Mrs. Kundu would be pleased to share WBPCB’s experiences under the CBIPMP regarding tendering and bidding process for appointment of consultants for site assessment and drawing up remediation plans. This is of interest for the project team as part of the Guidance document, so we agreed to discuss this subject in future during another mission of the project team.
The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

**METHODOLOGIES FOR NPRPS INDIA**

Site Visit Nibra Village, District Howrah, Kolkata, West Bengal, 2 July 2012

**Inputs:**
- West Bengal Pollution Control Board
- Mrs. Sarmistha Kundu, Environmental Engineer
- Site investigation report, 2005 by National Productivity Council (NPC),

**Purpose of site visit:**
For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the remediation approach that fits with different types of contaminated sites, listed in India.

**Review Points:**
- E. Location;
- F. Type of Waste;
- G. Size of site;
- H. Present Status of site;
- I. Owners;
- J. Social Issues and other environmental aspects;
- K. Earlier investigation of site

A. Location:
The Nibra village site is located in Howrah District a few kilometres after the Vidyasagar Setu (Vidyasagar Bridge) after crossing over the Hooghly River towards west of Kolkata. The site is located outside municipal boundaries and is near a small village with hutments, approachable by a narrow road which ends into a playground. The small village is set further after the playground.

B. Type of waste:
WBPCB has identified the site as a Hazardous Solid Waste dumpsite as a large volume of Chromium Ore Processing Residue (COPR) was dumped by unknown agencies to fill-up the site area from the year 1998 to year 2000 (as reported by NPC). The generators of the waste are unknown.

C. Size of site:
The site comprises of a field and a road leading to the village of total area approximately 0.73 Hectares as reported by NPC.
D. Present Status of site:
The site is a well levelled compacted ground, surfaced with some gravel. There are new buildings constructed on the site and in the village. There are ponds nearby and people take bath in these ponds. There is no visual evidence of hazardous waste at the site as the waste is fully covered under the soil and gravel material.

E. Owners:
Land owner is not known. Local village (Gram) Panchayat is the custodian of the public areas including the village approach road. The land use is not regulated and is decided by the land owners.

F. Social Issues and other environmental aspects:
Conversation with the villagers indicated that most are unaware of the presence of Hazardous waste in the soil where they have built their houses.
The village gets its drinking water from a bore well, dug deep, probably, through the waste dump within the village.
There are no known issues with the health of the villagers.

G. Earlier investigation of the site:
Site investigation was carried out in the year 2005 by the National Productivity Council (NPC), New Delhi and the investigation report was submitted to WBPCB in the year 2006.
Some features of the report are as below:
Surface Water- Hooghly River flows on the eastern side of the Howrah District.
Groundwater- Groundwater table in the district is generally high between 2m below surface post monsoon to 4m premonsoon.
Geology- The lithological exploration has been done by Central Ground Water Board near the site which is as follows:-

<table>
<thead>
<tr>
<th>Depth of formation starting at ground level (m)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.57</td>
<td>Clay, yellowish gray</td>
</tr>
<tr>
<td>17.58</td>
<td>Clay, gray hard</td>
</tr>
<tr>
<td>27.73</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>43.89</td>
<td>Sand, fine, yellowish gray</td>
</tr>
<tr>
<td>22.25</td>
<td>Sand, grayish white fine/ medium to coarse</td>
</tr>
<tr>
<td>24.79</td>
<td>Sand, medium to coarse grayish white</td>
</tr>
<tr>
<td>13.62</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>25.61</td>
<td>Sand, fine grayish white</td>
</tr>
<tr>
<td>12.8</td>
<td>Sand, grayish white medium</td>
</tr>
<tr>
<td>10.97</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>9.15</td>
<td>Sand, Fine Grayish White</td>
</tr>
<tr>
<td>3.64</td>
<td>Clay, gray</td>
</tr>
<tr>
<td>33.54</td>
<td>Sand, coarse, grayish white</td>
</tr>
<tr>
<td>14.63</td>
<td>Clay, dark gray</td>
</tr>
<tr>
<td>30.43</td>
<td>Sand, fine, grayish white</td>
</tr>
<tr>
<td>9.75</td>
<td>Clay, gray, silty</td>
</tr>
</tbody>
</table>

(Source: Report on selection of tube well site for FCI at Damduni, Hooghly District, Central Ground Water Board, Eastern Region, July 1988)

Monthly Rainfall in mm in Kolkata region as recorded by Kolkata Meteorological Centre is as below:
Characteristics of waste as reported by NPC is as below:

<table>
<thead>
<tr>
<th>pH</th>
<th>Cd</th>
<th>Cu</th>
<th>Pb</th>
<th>Ni</th>
<th>Cr (T)</th>
<th>Cr (vi)</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>BDL</td>
<td>10.0 - 12.2</td>
<td>11.4 - 12.2</td>
<td>905.3 - 978.2</td>
<td>27120 - 305500</td>
<td>598 - 1056</td>
<td>174.8 - 213.8</td>
</tr>
</tbody>
</table>

Parameters in TCLP, mg/l

|  | 0.14 - 0.19 | 0.51 - 1.07 | 1.47 - 1.87 | 3.72 - 10.49 | 46 - 77.8 | 468 - 842 | 10.56 - 12.5 |

Parameters in 1:10 water eluate, mg/l

| 10.7 - 12.5 | BDL | BDL - 0.004 | BDL | 0.011 - 0.021 | 46 - 260 | 2 - 255.41 | 0.039 - 0.044 |

Total contaminants in soil are as below:

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Parameters in mg/kg on dry weight basis</th>
<th>Cd</th>
<th>Pb</th>
<th>Zn</th>
<th>Cu</th>
<th>Cr (T)</th>
<th>Ni</th>
<th>Cr (vi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSL-04</td>
<td>BDL</td>
<td>10.8</td>
<td>64.1</td>
<td>25.5</td>
<td>32</td>
<td>24.7</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>315GL/1(4)</td>
<td>BDL - 0.7</td>
<td>33.6 - 36.7</td>
<td>74 - 90.9</td>
<td>55.7 - 78</td>
<td>42.2 - 46</td>
<td>37 - 39.3</td>
<td>BDL - 1.5</td>
<td></td>
</tr>
<tr>
<td>315GL/2(4)</td>
<td>BDL</td>
<td>27 - 31</td>
<td>82 - 86.2</td>
<td>42.8 - 61</td>
<td>37.8 - 56</td>
<td>32.3 - 52</td>
<td>BDL - 1.3</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>13 - 34.5</td>
<td>51 - 58.3</td>
<td>27.2 - 40</td>
<td>31 - 36.2</td>
<td>20 - 27</td>
<td>BDL - 5.5</td>
<td></td>
</tr>
<tr>
<td>315GL/4(4)</td>
<td>BDL</td>
<td>7.8 - 24.3</td>
<td>27 - 30.6</td>
<td>15 - 35.4</td>
<td>24 - 31.14</td>
<td>12 - 25.3</td>
<td>BDL - 0.54</td>
<td></td>
</tr>
<tr>
<td>315GL/2(4)</td>
<td>BDL</td>
<td>27.6 - 30</td>
<td>76 - 79</td>
<td>44.1 - 79</td>
<td>33 - 38</td>
<td>36</td>
<td>BDL - 1.25</td>
<td></td>
</tr>
<tr>
<td>315GL/2(4)</td>
<td>BDL</td>
<td>37 - 57.7</td>
<td>80</td>
<td>57 - 66.14</td>
<td>39.15 - 55</td>
<td>32 - 43</td>
<td>BDL - 0.48</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>11 - 16.9</td>
<td>42.2 - 47</td>
<td>13.6 - 34</td>
<td>12 - 21.2</td>
<td>15.8 - 20</td>
<td>BDL - 0.64</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>6 - 36.51</td>
<td>30</td>
<td>17 - 49.94</td>
<td>10 - 40.13</td>
<td>10 - 34.85</td>
<td>BDL - 0.28</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>25 - 29.5</td>
<td>67.1 - 76</td>
<td>27.6 - 60</td>
<td>41.2 - 69</td>
<td>24.6 - 48</td>
<td>7 - 8.9</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>30.4 - 41</td>
<td>59 - 83.95</td>
<td>42.53 - 66</td>
<td>44.6 - 64</td>
<td>37.21 - 53</td>
<td>BDL - 9.5</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>8 - 22.15</td>
<td>37 - 62.34</td>
<td>30 - 31.5</td>
<td>23 - 36.84</td>
<td>21 - 27.74</td>
<td>BDL - 15.3</td>
<td></td>
</tr>
<tr>
<td>315GL/3(4)</td>
<td>BDL</td>
<td>7 - 34.3</td>
<td>13 - 105.0</td>
<td>14 - 55.3</td>
<td>18 - 47.42</td>
<td>13 - 43.9</td>
<td>BDL - 2.55</td>
<td></td>
</tr>
<tr>
<td>315GL/4(4)</td>
<td>BDL</td>
<td>28.13 - 41</td>
<td>61 - 88.6</td>
<td>36.86 - 110</td>
<td>34.1 - 54</td>
<td>29.06 - 55</td>
<td>BDL - 0.83</td>
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</tr>
<tr>
<td>315GL/4(4)</td>
<td>BDL</td>
<td>31.45 - 37</td>
<td>68 - 102.7</td>
<td>42.11 - 65</td>
<td>40.25 - 62</td>
<td>32.69 - 35</td>
<td>BDL - 1.03</td>
<td></td>
</tr>
<tr>
<td>315GL/4(4)</td>
<td>BDL</td>
<td>9 - 34.81</td>
<td>37 - 120.3</td>
<td>24 - 52.5</td>
<td>16 - 53.61</td>
<td>19 - 46.2</td>
<td>BDL - 0.33</td>
<td></td>
</tr>
<tr>
<td>315GL/4(4)</td>
<td>BDL</td>
<td>5 - 37.06</td>
<td>22 - 100.5</td>
<td>19 - 54.05</td>
<td>12 - 39.2</td>
<td>6 - 36.1</td>
<td>BDL - 0.92</td>
<td></td>
</tr>
</tbody>
</table>

Leachable contaminants in soil are:
Water soluble contaminants are:

The reported results on groundwater and surface water are:

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>pH</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Cd</th>
<th>Cr (VI)</th>
<th>Cr (T)</th>
<th>Ni</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSW/08</td>
<td>7.43</td>
<td>92.31</td>
<td>8.1</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.03</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>SW/1(1)</td>
<td>7.85</td>
<td>NA</td>
<td>NA</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.003</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>SW/1(3)</td>
<td>8.14</td>
<td>NA</td>
<td>NA</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.001</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>SW/1(5)</td>
<td>7.85</td>
<td>NA</td>
<td>NA</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.002</td>
<td>BDL</td>
<td>BDL</td>
</tr>
</tbody>
</table>

Ground Water

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>pH</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Cd</th>
<th>Cr (VI)</th>
<th>Cr (T)</th>
<th>Ni</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSW/10</td>
<td>7.38</td>
<td>287.8</td>
<td>12.44</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.006</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>KGW/11</td>
<td>7.26</td>
<td>456.9</td>
<td>18.67</td>
<td>BDL</td>
<td>BDL</td>
<td>BDL</td>
<td>0.004</td>
<td>BDL</td>
<td>BDL</td>
</tr>
</tbody>
</table>

(*) All the parameters are in mg/l except pH; NA = Not analyzed

Sediment analysis of surface water was carried out and the results reported for water soluble sediments are:

Results of leachable sediments are:
The impact of waste disposal on surface water and ground water is pictured schematically below:

Conclusions:
The project team gained useful information for this type of contaminated sites near to residential areas where waste material is used for land levelling and road construction purposes. Some tentative options for the management of such sites were discussed during the site visit with Mrs. Kundu. Technical as well as social aspects were part of this discussion.
The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

**METHODOLOGIES FOR NPRPS INDIA**

**Site Visit Hooghly area, District Hooghly, West Bengal, 2 July 2012**

**Inputs:**
- West Bengal Pollution Control Board
- Mrs. Sarmishta Kundu, Environmental Engineer
- Site investigation report, 2006 by National Productivity Council (NPC),

**Purpose of site visit:**
For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the contaminated site assessment and remediation approach that fits with different type of contaminated sites.

**Review Points:**
- **L.** Location;
- **M.** Type of Waste;
- **N.** Size and present status of site;
- **O.** Owners;
- **P.** Social Issues and other environmental aspects;
- **Q.** Present assessment.

**H.** Location:
Alongside the road leading from Kolkata to Delhi in Hooghly district the area has varied users: residential area as well as industrial area (agricultural use also). There are some very large industrial sites. Few of the sites are closed.

In 2006 a report of National Productivity Council reported 7 contaminated sites in the area along an approximately 15 km stretch of the road (presently State Highway 13) from Kolkata to Delhi. At these 7 sites residues of chromium ore processing were found. The State Highway is situated about 1-2 meters above the adjacent area. Next to the road there are water bodies (ponds), maybe artificially made when material was excavated for construction of the road (highway).

We visited two sites with numbers 3 and 4 according to the NPC report. Site 3: Delhi Road, near Shivang Trexium Pvt. Ltd (now renamed Fortune Furnitech) & Shree Balaji Veneers Pvt. Ltd, Netaji More, Dist. Hooghly. Site 4: Delhi Road (100 m from Netaji More), Near Minu Weighbridge and Dhaba, Dist. Hooghly.

**I.** Type of waste:
The contamination has taken place due to use of waste material of Chromium Ore Processing Residue (COPR) as construction material (most probably between 1995 and 2005) to raise the ground level for infrastructure and buildings and to get a good connection between the residential and industrial premises and the high lying State Highway. The waste material was produced by many chrome chemical manufacturing industries in Hooghly district that already stopped production years ago. In Hooghly district only one chromium ore processing industry is still present and this unit disposes hazardous wastes to the authorized HWTSDF in the state.

**J.** Size and present status of site:

**Site number 3:** the approach roads leading to two industries have been made up of chrome waste with a possibility of other waste types having been used in the lower layers. Detailed underground investigations are expected to throw light on the exact scenario. The roads are now capped with asphalt. One hand pump and an open well is located just adjacent to the dumpsite. There are several ditches filled up with water adjacent to it. We visited the area of one of these industrial sites, engaged in furniture making. Behind the gate of the industrial premises the soil
is partly covered with granular material of different size and origin. At some spots the surface had a yellow colour. Near the surface the walls of some of the buildings had yellow-green spots. According to the NPC report the area is about 0.2 ha (industrial land not included) and the depth of the waste material and contaminated soil is 3 meters with an assumed quantity of 6,000 m$^3$ (see figure 4.7 of NPC-report, 2006). Then measured Total Chromium concentration of the waste material was about 16,000 mg/kg dry weight of which maximum of 3,300 mg/kg with Chromium VI. In the surrounding soil contamination with Chromium was found. In surface water and groundwater contamination was within limits of Drinking Water Standards.

![Site Map & Location of Soil (KSL), Groundwater (KGW), Surface Water (KSW) and Sediment (SED) Sampling Points](image)

Pictures Showing Chromium VI presence at Site number 3 & surrounding at Site number 3

Site number 4 is an access road leading to some houses and the Minu Computer Weighbridge. Comparing the situation with the map of the 2006 report it is clear that these houses have been built on the spot at a later date. Near the surface the white walls of the residential buildings are green-yellow coloured, so it is estimated the waste material is still laying below the houses. Alongside the access road, at the slope to the pond other construction material (broken pottery) is situated there. According to the NPC report the area is 0.17 ha and the depth of the waste material is 0.5-3 meters with an assumed quantity of 2,000 m$^3$ (see figure 4.7 of NPC-report, 2006). Then measured Total Chromium concentration of the waste material was about 26,000 mg/kg dry weight of which maximum of 2,600 mg/kg with Chromium VI. In the surrounding soil contamination with chromium was found. In surface water and groundwater contamination were found below limits of Drinking Water Standards.
K. Owners:
Site number 3 is a small access road leading to an industrial site, nowadays making wooden articles. The access road is built on PWD land but the industrial land is privately owned. Mrs. Kundu explained that she expects the owner still does not know his site is probably contaminated but in future after the detailed investigations are completed, WBPCB will need to inform him to ensure necessary clean-up.
The area in front of the contaminated site number 4 is owned by PWD but the residential houses and the weighbridge are private properties.

L. Social Issues and other environmental aspects:
On site number 4 houses have been built. It is not known at this moment if people have knowledge of the soil contamination of their premises. Workers engaged in the industries and weighbridge are constantly exposed to the chromium waste through skin contact, inhalation and possible ingestion. Vehicles using the weighbridge are spreading the contamination as the loose waste road-fill is being carried over by the wheels and also causes resuspension of the waste dust leading to air pollution. During the rains, the waste gets carried to other areas including nearby agricultural land and surface water bodies along with surface run-off.
There appears to be a clear preference for such industrial wastes for road construction and land-filling in the said area. A large number of potentially contaminated spots have already been identified and recent instances of such landfilling have also been detected by the WBPCB. The
general ignorance of people, including the administration, is an important social aspect of the project. Such widespread use of industrial waste will eventually raise social costs and influence choice of remediation technology in case serious health impacts are predicted through detailed assessments.

Use of industrial waste to build access roads over public land and obstruction of drainage canals is also a matter of public concern. It is fairly clear that the number of industries in the area is increasing fast and there is an obvious tendency in the region for conversion of farm land to industrial land. Industrial infrastructure development, drainage and sewerage issues, access/service road development etc. are allied social and environmental needs.

With the above context, it is necessary to assess the social cost and cost of suitable remedial measures of the sites. The social cost may significantly increase if remediation measures require relocation of habitation and industries.

Planning for infrastructure and specific roles and responsibilities of the institutions (line govt. departments) should be addressed to reduce social cost.

Documentation of the health hazards is necessary to prioritize the need for remediation.

Govt. policy is required to regulate land use pattern.

M. Present assessment:
Site assessment is currently being carried out by ERM using several techniques e.g. Vertical Electrical Sounding (survey coverage thickness), techniques as XRF (pre screening in field before selecting lab samples) and classical sampling and lab testing. The lab testing is carried out in a third party laboratory, approved by the government (to meet requirements of legal procedures). The WBPCB lab is well equipped but not adequately staffed to handle the large number of samples and test the extremely broad range of specific contaminants. Samples are being analysed on 50 parameters as the heterogeneous waste may contain several sources and thus several contaminants. The consultant has till now identified 27 potential Chromium contaminated sites (hot-spots) spread over 18 sq. km. along the road through XRF screening. Detailed investigations will help in establishing the level and extent (spread) of contamination.

A site assessment should meet an integrated approach among which the complete source-pathway-receptor. A broad range of data is needed. Much data is already available, e.g. geohydrological data can be gained from the Central Groundwater Board.

WBPCB archives will not cover all permits for HW producing industries as the PCB is founded in 1976 and initially was focused on other environmental issues (Water Act- 1976, Air Act- 1981). Hazardous Waste Rules were notified only in 1989.

Conclusions:
The project team gained useful information for this type of contaminated sites near to industrial and residential areas where waste material is used for construction purposes. Some tentative options for the management of such sites were discussed during the site visit with Mrs. Kundu.

Technical as well as social aspects were part of this discussion.
The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

METHODOLOGIES FOR NPRPS INDIA

Site Visit Dhapa, Kolkata, West Bengal, 3 July 2012

Inputs: 
Mr. Debajyoti Bhaumik, Project Engineer (MSW), CBIPMP 
West Bengal Pollution Control Board 
Mr. Mehul Petkar, Assistant Consultant 
Kadam Environmental Consultants, Vadodara Partner to CAT alliance Ltd.

On the instance of World Bank during the TEP Workshop in Delhi on 28 June 2012, the Dhapa Municipal Waste Dump site in Kolkata was visited by the project team on 3 July 2012. The site is under the World Bank CBIPM Project and is under remediation on pilot basis. It is anticipated that the project will result in significant environmental benefits i.e. improvement in water and air quality, improved hygienic conditions, health benefits such as reduction in water borne, vector borne diseases and economic benefits i.e. employment generation during rehabilitation and remediation.

For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the remediation approach that fits with the different types of contaminated sites, listed in India.

The Dhapa site is Kolkata Municipal Corporation’s (KMC) Municipal Solid Waste Old landfill site located about 10 km south-east of Kolkata city. Total area of landfill site is 12.500 Hectares. The disposal site is shaped long and thin from west to east with a size approximately of 150 m by 2,000 m. The depth of the waste dump is approximately 29m.

In compliance with the East Kolkata Wetland Management Plan the site is identified for closure and rehabilitation. The post rehabilitation land use has been defined by the East Kolkata Wetland Act which prohibits any commercial developments.

The site contains unsegregated waste, including organic waste, debris and some recyclable refuse. Surface and ground water is contaminated by the leachate from the dump site reaching the nearby water bodies.

The remediation plan envisages capping of the disposal site and capture of land fill gas. The site remediation/rehabilitation plan is designed to mitigate health hazards from toxic pollution, which poses risks to community and ecology (especially humans and animals that come into direct contact with the waste); reduce water and soil contamination in the land surrounding the site, which is used for small farming. Remediation also would improve the aesthetic appearance of the natural area, help eliminating the nuisance of flies and other insects that breed intensively on the site, and very likely lower the incidence of environment-related disease.

The proposed plan to close and reclaim the waste dump site is also expected to result in potential cost-savings with decreased levels of pollution in soil, potential cost savings with decreased health budget from lower incidence of environment-related disease. Improvement/better management of the site would make it easier to set up transportation facilities and roadside amenities, which would generate income.

A social assessment has identified dangers posed to public safety from toxic waste at the contaminated sites, including health hazards due to open dumps and unmanaged/inadequate solid waste collection, dumping, and treatment services. 700 rag-pickers derive their livelihoods collecting waste at the Dhapa MSW sites and will lose their income upon closure of the sites. There is pollution of the ambient environment due to burning of solid waste (air pollution) and
contamination of water sources. There is also degradation of natural and cultural resources and lack of attention to their preservation. There is child labour, particularly at the dumpsites.

The site is presently being monitored for waste composition, metal contaminants, hydrogeology, groundwater contamination etc. by an agency assigned by WBPCB for the CBIPM Project. Therefore this agency is making bore holes to depths of about 50 meters. Groundwater samples will be investigated on various parameters in a laboratory. Also samples of soil and surface water will be investigated.

In the soil from 0 to 47 meters below surface the soil mainly consists of clay. From 47 to 60 meters sandy layers are present.

There is also a Fertiliser Manufacturing Factory as well as the Municipal Crematorium near the Dumpsite.

**Conclusion site visit:**

Although the Dhapa site is a specific waste management site that is not on the CPCB-list of hazardous waste contaminated dump sites, the project team gained useful information on this type of contaminated sites where municipal waste potentially contains hazardous waste as well. Some tentative options for the management of such sites were discussed with Mr. Bhaumik during the site visit.
7.4 Annexure 4 Overview of the sites analyzed using the standard site factsheet

The following sites have been analyzed using the standard site factsheets.

- GPCB 000-002 Unknown Industries, Valad, Gujarat
- GPCB 001-001 Hema-II, Vadodara, Gujarat
- KSPCB 002-003 Insecticide Company, Eloor, Kerala
- MPPCB 000-004 Vitamin Company, Ratlam, Madhya Pradesh
- MPPCB 003-004 Chemical Company, Ratlam, Madhya Pradesh
- OSPCB 004-006 Chemical Company, Ganjam, Orissa
- OSPCB 005-009 Chemical Company, Talchar, Orissa
- OSPCB 006-010 Chemical Company, Sundargarh, Orissa
- OSPCB 013-012 Fertilizer Company, Mayurbanj, Orissa
- PSPCB 014-013 Humbran Road, Ludhiana, Punjab
- RSPCB 007-016 Chemical Company and other, Bichhadi, Rajasthan
- TNPCB 008-018 Chemical Company, Ranipet, Tamil Nadu
- TNPCB 015-017 Chemical Company, Kodaikanal, Tamil Nadu
- UPSPCB 09-019 Pesticide Company, Lucknow, Uttar Pradesh
- UPSPCB 010-021 Chemical Waste site, Kanpur, Uttar Pradesh
- UPSPCB 011-0023 Chemical Waste site, Kanpur, Uttar Pradesh
- WBPCB 012-024 Nibra Village, West Bengal

Annexure 4a, presented in a separate annexure report to this report, contains the site factsheets on these sites.
7.5 Annexure 5 References

Literature
- Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit (UNIDO, 2009);

Lists of contaminated sites
- CPCB (reference not specified) - List of 12 priority contaminated dump sites (Annexure 6);
- CPCB (reference not specified) - List of 25 hazardous waste dump sites (Annexure 7);
- Blacksmith Institute, 2007a - Polluted Sites - India;
- Blacksmith Institute, 2007b - A compilation of polluted places India; Initial site assessment reports’, supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program;
- Blacksmith Institute, dynamic source through internet, referenced September 2012 - Toxic Sites Identification Program, Global Database (http://www.dbisa.org/isa/in/). Accessed through login with the kind permission of the Blacksmith Institute.
7.6 Annexure 6  CPCB List of 12 priority contaminated dump sites

A reference to the CPCB List of 12 priority contaminated dump sites could not be located.

CHAPTER 1

1.0 Background

There are several contaminated dump sites in various parts of India where hazardous wastes was dumped by various industrial units, which resulted in contamination of soil and groundwater thereby posing severe health and environmental risks. These contaminated dump sites needs to be remediated on priority and restored in an environmentally sound manner through appropriate remediation technologies, to safeguard human health and environmental safety. This note contains an implementation methodology along with the institutional and legal frame work for remediation of hazardous waste contaminated dump sites through engagement of technologically and financially competent entities having techno-economical viable solutions.

An initial inventory of such illegal hazardous waste dump sites in the country has been prepared by the Supreme Court Monitoring Committee (constituted by the Hon'ble Supreme Court of India in the matter of Writ Petition (Civil) No. 657 of 1995), is perhaps a first compilation of such sites in India. Central Pollution Control Board (CPCB) has further updated the list of such sites as per information received from SPCBs/PCCs, the list of such sites having preliminary information is Table-1 below. The details of the above illegal hazardous waste sites are given in Annexure-1.

Table 1: Hazardous Waste Contaminated Dump Sites

<table>
<thead>
<tr>
<th>State</th>
<th>Current Number of Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>-</td>
</tr>
<tr>
<td>Assam</td>
<td>-</td>
</tr>
<tr>
<td>Delhi</td>
<td>21</td>
</tr>
<tr>
<td>Gujarat</td>
<td>2</td>
</tr>
<tr>
<td>Karnataka</td>
<td>-</td>
</tr>
<tr>
<td>Kerala</td>
<td>4</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>4</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>-</td>
</tr>
<tr>
<td>Orissa</td>
<td>21</td>
</tr>
<tr>
<td>Punjab</td>
<td>5</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>1</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>2</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>5</td>
</tr>
<tr>
<td>West Bengal</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>73</strong></td>
</tr>
</tbody>
</table>

The list of contaminated sites identified by SPCBs having preliminary information/data on the type of waste dumped and nature of contamination is given at Annexure-I. Based on the quantum of waste dumped, extent of groundwater/soil contamination, nature of pollutants, ecological and health impacts, the following 12 contaminated sites (Table – 2) may be designated as priority contaminated dump sites in the country, which require immediate attention.
The priority of sites is arrived based on the following criteria:

- a. Constituents of contamination (inorganic salts < toxic metals < POPs)
- b. Ground water contamination (exceeding drinking water norms)
- c. Affected population, flora / fauna
- d. Health & Ecological impacts

### Priority Hazardous Waste Contaminated Dump Sites

<table>
<thead>
<tr>
<th>S.No</th>
<th>State</th>
<th>Name of Site</th>
<th>Nature of Contaminant</th>
<th>Preliminary details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gujarat</td>
<td>Vadodara</td>
<td>Chromium</td>
<td>Approx. 77000 tonnes of chromium residue is dumped in industrial plot. Groundwater is contaminated.</td>
</tr>
<tr>
<td>2</td>
<td>Kerala</td>
<td>Eloor, Cochin</td>
<td>Heavy metal and POPs</td>
<td>24.5 hectares of soil and water bodies contaminated with Pesticides and heavy metals in 4 locations.</td>
</tr>
<tr>
<td>3</td>
<td>Madhya Pradesh</td>
<td>Ratlam</td>
<td>Gypsum, iron salts and Naphthalene</td>
<td>Severe contamination of ground water with PAH and Iron salts imparting red colour.</td>
</tr>
<tr>
<td>4</td>
<td>Orissa</td>
<td>Ganjam</td>
<td>Mercury</td>
<td>About 56,000 MT of sludge containing mercury dumped along and near the banks of the river Rishikalya.</td>
</tr>
<tr>
<td>5</td>
<td>Orissa</td>
<td>Talcher</td>
<td>Chromium</td>
<td>60000 tonnes of chromium leach residue is dumped in closed industry premises. Contamination of soil, and surface water bodies during rains.</td>
</tr>
<tr>
<td>6</td>
<td>Orissa</td>
<td>Sundergarh</td>
<td>Chromium</td>
<td>Chromium leach residue dumps at 4 locations.</td>
</tr>
<tr>
<td>7</td>
<td>Rajasthan</td>
<td>Bichhadi</td>
<td>Inorganic salts, organics</td>
<td>Contamination of soil and groundwater.</td>
</tr>
<tr>
<td>8</td>
<td>Tamil Nadu</td>
<td>Ranipet</td>
<td>Chromium</td>
<td>Hexavalent Cr leaching from 7.41 acre dumpsite, with 2.2 lakh MT of leach residue. Soil and groundwater and surface water contamination.</td>
</tr>
<tr>
<td>10</td>
<td>Uttar Pradesh</td>
<td>Rania, Kanpur Dehat</td>
<td>Chromium</td>
<td>Area 2 sq. km. Private land is contaminated with open dump of Approx. 45000 tonnes of waste.</td>
</tr>
<tr>
<td>11</td>
<td>Uttar Pradesh</td>
<td>Lucknow</td>
<td>HCH (hexa chloro cyclo hexane)</td>
<td>Approx. 36432 tonnes of pesticides waste dumped in closed industry premises.</td>
</tr>
<tr>
<td>12</td>
<td>West Bengal</td>
<td>Nabra Village, Howrah</td>
<td>Chromium</td>
<td>About 4440 tonnes of residue dumped, human settlement exists above the dump, contamination of groundwater.</td>
</tr>
</tbody>
</table>
7.7 Annexure 7  CPCB - List of 25 hazardous waste dump sites

A reference to the CPCB List of 25 hazardous waste dump sites could not be located.

ANNEXURE
Andhra Pradesh

APPCB (Andhra Pradesh Pollution Control Board) entrusted a project to EPTRI (Environment Protection Training and Research Institute), Hyderabad for identification of illegal hazardous waste dump sites in Andhra Pradesh in the year 1999. From the identified sites, about 24,000 tonnes of the illegally dumped hazardous solid waste was lifted and disposed in TSDF (Treatment, Storage, Disposal Facility) established by HWMP (Hyderabad Waste Management Project) at Dundigal, R.R. District in 2001.

APPCB has further identified 16 nos. of isolated illegal dumps from 2001 to 2009. About 4095 tons of the hazardous waste dumped in the above 16 sites was transported to TSDF and the identified offenders were made to pay the disposal charges to TSDF. The analysis reports of random soil samples collected from these sites, indicated that the soil at these sites is not contaminated.

5 fresh dump sites have been further identified having traces of hazardous wastes. The central laboratory, APPCB is carrying out the quantification and characterisation of these dump sites for taking further action.

Assam

PCBA (Pollution Control Board, Assam) has reported 92 nos. of hazardous waste dump sites within 9 industrial units. However, all these dump sites are apparently pits/lagoons/secured landfill/bio-remediation sites and are located within the premises of industries, which are operational. These sites are existing in the following industries

- Hindustan Paper Corporation Ltd., Nagaon Paper Mill, Morigaon,
- Hindustan Paper Corporation Ltd., Cachar Paper Mill, Panchgram, Hailakandi
- Numaligarh Refinery Ltd., Golaghat
- Indian Oil Corporation Ltd., Noonmati, Guwahati
- Indian Oil Corporation Ltd., Digboi Refinery, Digboi, Tinsukia
- Brahmaputra Valley Fertilizer Corporation Ltd., (BVFL) Namerup
- Indian Oil Corporation Ltd, Bongaigaon Refinery, Dhaligaon,
- Oil India Ltd., Duliajan
- Oil & Natural Gas Corporation Ltd., Nazira

Delhi

DPCC (Delhi Pollution Control Committee) had engaged Ramky Infra Consulting Pvt. Ltd., for study and preparation of report for ‘Inventory of Hazardous Waste Generation by Industrial Units in Delhi’, who has reported 23 illegal hazardous waste dump sites in Delhi in their report submitted to DPCC.
CPCB constituted Expert Committee visited three illegal hazardous waste dump sites on 24-11-2009, and observed the presence of industrial waste, which is also mixed with municipal solid waste. The Expert Committee recommended carrying out analysis of the industrial wastes laying at all the 23 sites and depending upon the waste characteristics after the analysis report, the mode of disposal and remediation plan shall be worked out and executed by DPCC. Immediate fencing of the sites was also suggested to stop further illegal dumping of the waste.

**Gujarat**

GPCB (Gujarat Pollution Control Board) as a part of action plan for the years 2000-01 and 2001-02 has reportedly contained about 6 MMT of waste at 5 locations. Lifting and shifting of 0.025 MMT of waste consisting iron waste, gypsum waste, carbon waste, old chromium waste, tarry waste, ETP sludge and chalk had been carried out from total 77 locations. Fresh inventory was undertaken as per Honorable Supreme Court order and 22 dump sites were identified. About 34,000 tonnes of waste was lifted and shifted to TSDF from around 15 sites at approximate cost of 1.43 crores. This was accomplished on the basis of identification of probable culprits, co-operation of TSDF authorities, industrial associations and enforcement of the principle of “Polluter Pays”.

Illegal hazardous waste from 4 of the remaining 6 sites, have been lifted and shifted to TSDF. The remaining two sites i.e. one site at Valad, Dist. Gandhinagar has been taken up by the World Bank for detailed assessment and remediation in consultation with MoEF (Ministry of Environment & Forests). The consultants appointed by the MoEF under WB (World Bank) scheme have started their study.

GPCB has prepared final report of the rehabilitation plan pertaining to the site of Hema chemicals (Unit-II), Vadodara (one of the remaining seven sites that requires remediation), which is contaminated with chromium (VI).

**Karnataka**

The KS PCB (Karnataka State Pollution Control Board) identified two sites for rehabilitation i.e. dump site located at Bommasandra Industrial Area, Bangalore and Koratagere Taluk, Dist. Tumkur. The GTZ (German Technical Cooperation), with whom the Board has technical co-operation, carried out the study of Bommasandra area and prepared a report. As per the report, 85% of the waste is non-hazardous and remaining 15% is hazardous (only 1% is toxic). KS PCB is of the view that Bommasandra dump site is not considered as a serious threat to the environment and requires no immediate remediation. The waste from the Tumkur site was removed from the site and disposed in TSDF established at Dabaspet for landfilling. KS PCB has spent Rs. sixteen lakhs forty thousand of its own funds for the remediation of the waste dump.

**Kerala**
Kerala State Pollution Control Board has identified four dump/contaminated sites. The Kuzikandom thodu and Ammenthuruthu sites in Kerala are contaminated with heavy metals and POP (Persistent Organic Pollutants). The other two sites i.e. Edayattuchal and Chakkarkhal having total size of 30000 sq. m and 15500 sq. m respectively and are contaminated with having heavy metals and mixed waste respectively.

Industries such as Fertilizers and Chemicals Travancore Ltd., - Udyogamandalam division, Hindustan Insecticides Ltd., Indian Rare Earths Ltd and Merchem have dumped their solid wastes in low lying areas within their premises. The Leachate/spill-over from these wastes has reached the Kozhikandom thodu. The sediments collected from Kuzhikandum thodu contain hazardous constituents of wastes from the above units. The leachate and spill over from wastes of these units have also reached the nearby paddy fields like Ammanthuruthu and Karipadam, making those unsuitable for cultivation, which are now in abandoned condition. Binani Zinc Ltd has dumped their solid wastes along with jarosite in their premises in early days and the leachate has reached the nearby paddy fields like Edayattuchal and Chakkarkhal.

**Madhya Pradesh**

The 6 dump sites identified by the MPPCB (Madhya Pradesh Pollution Control Board) pertaining to 4 closed industries namely Sajjan Chemicals, Ratlam (responsible for 3 dump sites), Borda Chemicals, Ratlam, Jayant Vitamins Ltd., Ratlam, Beta Naphtol, Maksi).

Results of random monitoring of Ratlam region revealed surface & sub-surface (30 cm) soil within the premises of these industries were found to be contaminated with organics such as Naphthalene, Binaphthyle Sulfone, 1,2 Naphthylemethyline etc. Evidence of contaminants in the adjoining land parcels was found during preliminary examination.

Results of the analysis of Maksi region, Shajapur revealed surface & sub-surface (30 cm) soil within the premises of the industry to be contaminated with organics such as naphthalene, sulphur, amines & phenols etc. No evidence of contamination was found in the adjoining land parcels during preliminary examination.

**Maharashtra**

MPCB (Maharashtra Pollution Control Board) explored the possibility of using remote sensing techniques for the identification of illegal hazardous waste dump sites. The work was outsourced to NRSA (National Remote Sensing Agency), Hyderabad.

**MIDC (Maharashtra Industrial Development Corporation) has set up a SLF (secured landfill) at Tarapur to encap approx. 1.5 lakhs MT of hazardous waste lying at the site.** This consists mostly of ETP (Effluent Treatment Plant) sludge, ash etc. accumulated over a period of 10 years. The hazardous waste (i.e. 1.5 lakh MT) dumped in MIDC area and out side of the MIDC area in Tarapur has been completely capped in the SLF.
Besides Tarapur, in other industrial areas, all identified smaller dumps were removed by lifting about 2085 MT of hazardous waste to common hazardous waste TSDF at Taloja. MIDC is reportedly providing alternate water supply to the villagers in the vicinity of MIDC areas.

**Orissa**

The SPCB, Orissa (State Pollution Control Board, Orissa) has identified 21 nos. of illegal hazardous waste dump sites in 6 locations within the state. The sites are located in the industries namely, Jayashree Chemicals, Ganjam (3 sites; Mercury contaminated), Orichem Ltd., Talcher (1 site; chromium contaminated), HINDALCO, Hirakud (3 sites; cyanide contamination), NALCO, Angul (3 sites), East Coast Fertiliser & Chemicals, Kalma (2 sites; fluoride and vanadium contamination), Kerbs & Cie Ltd., Kalma (5 sites), Lotus Chrome Chemicals, Rourkela, Sundargarh (1 site), Lotus orange chemicals, Rourkela, Sundargarh (1 site), Siddhartha Chemicals & Konark Chemicals (2 sites).

**Punjab**

The PPCB (Punjab Pollution Control Board) initially identified 32 illegal dump sites in the state of Punjab. After preliminary survey 20 sites have been ruled out as illegal hazardous waste dump sites by PPCB. PPCB has appointed Tetra Tech India Ltd., New Delhi for investigation of the remaining 12 sites.

In the report prepared by Tetra Tech, at seven sites (namely - On the bank of Patiala ki Rao Choe, Mohali; Along the banks of river Siswan, Kurail; MC disposal site, Kotkapura; Seed farm road, Abohar; Old Fazilka road, Abohar; Village Wariana, Kapurthala road; and Village Chugitti, Bye pass road, Jalandhar), no contamination of either soil or groundwater has been observed.

Out of the remaining 5 sites, two sites at Ludhiana i.e. Humbran and Tapiur road, and one site at Jalandhar i.e. Basti Sheik dump site are contaminated with organic pollutants, which may be due to municipal waste/hazardous waste.

**Rajasthan**

The State Board has identified only one hazardous waste dump site in the State at Bichhadi, Udaipur. Hindustan Agro Chemicals Ltd., Bhiwadi, Udaipur was in operation up to 1996 and discharged/dumped its hazardous waste generated by it and its subsidiary units namely Silver Chemicals, Jyoti Chemicals, Phosphate India and Rajasthan Multi Fertilizers in and around the premises of the industry. These units were manufacturing H-Acid, Sulphuric Acid, Oleum, Chloro sulphonic Acid, Phosphatic Fertilizers and other chemical.

**Tamil Nadu**

TNPCB (Tamil Nadu Pollution Control Board) has identified two sites located within the premises of – (i) Tamilnadu Chromates & Chemicals Ltd., Ranipet (TCCL), which
is contaminated due to disposal of chrome bearing waste (2.2 lakh tones) during its operation from 1975 to 1995, and; (ii) Hindustan Unilever Ltd., (HUL) Kodaikanal, which is contaminated due to deposition of air borne Mercury from thermometer manufacturing activity at site for 18 years, 1983 till closure in 2001.

- At HUL site decontamination of the machinery was started on 13th February 2006 and was completed on 7th May 2006. Materials of quantity 274.995 MT were decontaminated and dispatched to recyclers and approx. (4068 m³) 7400 MT of soil at the factory sites still remains to be remediated. Development of the remediation plan of the same under progress.

- At Tamilnadu Chromates and Chemicals Ltd., Ranipet, site assessment was carried by NGRI, Hyderabad and NEERI, Nagpur on behalf of TNPCB based on drilling, soil sampling & analysis. TNPCB has entrusted several reputed institutes such as NGRI (National Geophysical Research Institute), Hyderabad; NEERI, Nagpur; Sri Ramachandra University, Chennai and IIT (Indian Institute of Technology), Chennai to conduct thorough investigations related to geoenvironmental, remediation/rehabilitation work, health and bio-remediation assessments at the chromium contaminated site in and around TCCL, Ranipet. Reports in various stages have been submitted by the respective institutes in this regard to TNPCB. According to Geological Survey of India, the chromium contamination has spread up to a distance of 2 km on the southern side from the site.

- Rehabilitation plan for TCCL, Ranipet is not yet finalized, however, report prepared by TIDCO (Tamilnadu Industries Development Corporation) for decontamination of soil and containment facility. TIDCO, one of the joint venture of the unit in earlier period has furnished proposal for containment of chromate sludge at cost of `24.8 crores. The same was sent to MOEF, GOI for financial assistance under their R&D programme.

- Further TNPCB had prepared a project proposal for `80.35 crores, including spot monitoring of the site (TCCL). The said project proposal has been submitted to Principal Secretary to Government, Finance Department, secretariat vide letter dt 16.8.2010 requesting the World bank loan under Capacity building Industrial pollution management Programme assisted by the World bank through the MoEF, New Delhi.

**Uttar Pradesh**

The UPPCB (Uttar Pradesh Pollution Control Board) had identified 11 illegal dump sites within the state. The UPPCB appointed institute IITR (Indian Institute of Toxicology Research), Lucknow has submitted a detailed survey of all the illegal dump sites in UP.

Out of the 11 sites, one site at Bhowapur, Kaushambi, Ghaziabad was containing mostly municipal waste, which has been removed. At five other sites, no waste was
found lying within the premises of the respective industries (Brij Chemicals, Dinesh Chemicals, R.K. Industry, K.M. Chemicals, K.B. Industries, all from Mathura) and all units were permanently closed.

At two illegal dump sites i.e. Nauraiya Khera, Kanpur and Juhi Baburiya, Rakhi Mandi, Kanpur 15,000 tonnes and 10,000 tonnes of BCS (Basic Chrome Sulphate) waste containing chromium was illegally dumped.

At site situated in Panki Industrial area Kanpur Nagar, approx. 35,000 tonnes of wastes was dumped containing heavy metals. Wastes are of complex nature and consist of waste from dyes, foundries, leather manufacturing units, cotton textiles, carpet industries and municipal waste.

At Village Khanpur, Rania, Kanpur Dehat, approx. 45,000 tonnes of visible waste & BCS waste containing chromium was dumped over land, which is still lying at the village.

At dump site in Deva road, Lucknow, the responsible factory, Indian Pesticides Ltd. (IPL) has informed that the pesticides dumped in an old brick kiln is filled with muck up to the height of about 3 meters and topped up with the boiler ash & soil. Almost all the waste has been lifted from the abandoned brick kiln site at Deva Road and transferred to above TSDF.

**West Bengal**

WBPCB (West Bengal Pollution Control Board) has identified 8 nos. of illegal hazardous waste dump sites, which are located in the districts of Howrah and Hooghly. The sites are located in and around Nibra village, Dist. Howrah and along the Delhi road (NH2), Dist. Hooghly and containing mostly of wastes from bichromate manufacturing units contaminated with chromium and heavy metals. Assessment of these sites was done by NPC (National Productivity Council), New Delhi in the year 2005 by physical inspection, sampling and analysis. A second assessment was done by SENES Consultants India Pvt. Ltd. in 2008. Among the 8 sites, the World Bank and MoEF teams have selected 7 sites in Hooghly district, as a single cluster, for remediation.

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