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An Estimate of ContaminatedLand Area due to Industrial Hazardous Waste Generation in India

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Abstract
The rapid growth of industrialization, urbanization and use of pesticides in agricultural fields in India has contributed to the generation of contaminated land. The uncontrolled and non-engineered waste disposal is one of the major causes of ground water contamination, air contamination and land contamination leading to health risks of human beings, animals and ecosystems. This paper is mainly focused on estimating the land area rendered or prone to contamination due to industrial hazardous waste generation and disposal practices. Presently in India, there is reported 7.2 million tonne hazardous waste generation from more than 40,000 registered industries according to Controller and Auditor General's report(CAG-2012) and there is no estimate of unregistered hazardous waste generating industries. This industrial hazardous waste has recyclable, landfillable and incinerable components. In this study an effort has been made to estimate the land area being contaminated due to landfillableportion of hazardous waste. The reason is that the cost of land areas is very high in urban area and remediation of such contaminated land puts an additional cost on it and without remediation, there is major health risk in using such land areas. In Indian context, there are 29 Treatment, Storage and Disposal Facilities (TSDF) in 16 states to treat thehazardous waste generated in nearby areas.These treatment facilities have not sufficient capacity to handleall the hazardous waste generated every year. The cost involved in handling, transportation and treatment on one hand and inadequate capacity of treatment facilities on the other have led to illegal dumping of hazardous waste which has become the major source of land contamination.

Keywords
Contaminated Land, Hazardous Waste,Treatment Facilitiesand Waste Generation.

I. Introduction

Land is the upper portion of the earth's surface which is directly exposed to nature and interacts with the human beings. This portion of earth is affected by a number of human and natural activities. During these activities the natural composition of soil components is prone to changes. If the quantity of chemicals and other substances present in the soil are more than a threshold limit and the soil becomes hazardous to the human being and ecosystem then it is called contaminated land. Contaminated land is basically generated by deposition and interaction of different types of wastes (solid, sludge and liquid forms).

Contaminated land is largely the result of improper disposal of waste or chemicals onto the land from the industrial activity.These chemicals may also be in the form of pesticides, insecticides and fertilizers used in agricultural practices. Mining waste disposal practice is another major cause of land contamination and once these chemicals exceed a limit, this land become hazardous for human health. Also, due to urban growth such contaminated land may become a partof human habitat and thenit becomes a substantial health hazard.

Environmental protection act 1990 defines "Contaminated Land" as

"Contaminated land" is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that—

(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or
(b) Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.

Land can become contaminated and a health risk when the hazardous substances are not disposed off in a safe manner. Contamination is not always limited the specific region. It may spread out to nearby land, surface water bodies and ground water. Hazardous substances may seep through the soil into ground water or be carried to nearby land and waterways through rainwater or transported through air.

Contamination of land may be due to the disposal variety of wastes and chemicals on or in the soil.Sources of land contamination could be several. Some contamination sources are listed as follows:

1. Industrial hazardous waste
2. Electronic waste
3. Municipal waste
4. Disposal of coal ash
5. Construction and demolition waste
6. Agricultural practices
7. Accidental disasters and oil spills
8. Chemical and nuclear plant waste
9. Chemical waste due to dismantling of ships
10. Illegal importing hazardous waste
11. Oil refineries

The scope of this study is limited to industrial hazardous waste generation and land being contaminated due to the component of hazardous waste not treated in the disposal facilities.

II. Industrial Hazardous Waste Generation in India

Due to increase in population, the demand for food, housing and other goods have grown tremendously resulting in requirement of higher production and consequently in industrialization. This growing industrialization has led to generation of increasingly higher quantities of waste, a major portion of which is disposed off in unengineered manner and this has become the major source of land contamination.

Table 1.presents a select list of hazardous waste generating industries and type of waste generated by them.

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Table1 : Hazardous waste generating industries and type of waste generation. (Environmental Protection Agency, 1986)

WASTE GENERATOR	WASTE TYPES
Chemical Manufacturers	Acids and Bases Spent Solvents Reactive Waste Wastewater Containing Organic Constituents
Printing Industry	Heavy Metal Solutions Waste Inks Solvents Ink Sludge Containing Heavy Metals
Petroleum Refining Industry	Wastewater Containing Benzene & other Hydrocarbons Sludge from Refining Process
Leather Products Manufacturing	Toluene and Benzene
Paper Industry	Paint Waste Containing Heavy Metals Ignitable Solvents
Construction Industry	Ignitable Paint Waste Spent Solvents Strong Acids and Bases
Metal Manufacturing	Sludge containing Heavy Metals Cyanide Waste Paint Waste

The contamination can take a variety of forms;therefore its impact also can bein variety of ways. Depending upon the type of contaminant present in thesoil, its concentration and the pathway through which it reaches the target and consequent risk level one can predict the harm which may be caused to human health, crop, property and ecological system.

Land contaminants include both chemicals and pathogens. These contaminants may cause a variety of health problem starting with minor problems like headaches, fatigues, skin rash, and eye irritation to major health issue e.g.

- Cancers: through land contaminated with chemicals (e.g. Gasoline or other petroleum products containing benzene).
- Nervous system damage: especially by lead in soil affecting especially children.
- Neuromuscular blockages.
- Kidney and liver damage: caused by chemicals such as Mercury.
- Problems in the respiratory system
- Problems of skin
- Long term illness

And the ultimate risk of death and Genetic effects.

In case of ecosystem, land contaminants can negatively affect the plant, animal health and microbial activities. Some contaminants may change the plant metabolic processes and reduce yield or cause visible damage to crops.

Contaminated land also generates the following problems which also affect the cost, health as well as aesthetics of the land area.

- Bad smells and odour.
- Contamination of ground water.
- Fire or explosion hazard.
- Effect on aquatic plants and animal life.
- Toxicity in vegetablesproduced.

Dutt et. al. (2006) has summarized the health effect of hazardous waste as presented in **Table2**.

According to the report of **Supreme Court Monitoring Committee (2004),**The number of industries issued authorization by Andhra Pradesh Pollution Control Board (APPCB) had gone up from 1,286 in January 2004 to 1,532 in October 2004 and the total quantity of hazardous waste generated rose from 1,45,000 tonnes per annum to 2,42,706 tonnes per annum. The data provided by APPCB that recycled, disposed and incinerable portion of hazardous waste is of 52.1%, 45.4% and 2.5% respectively which is different than the figures reported for generated waste in the three categories in other states where there are equivalent industries. According to **Pappu, Saxena and Asolekar (2007),** the total waste generation in India is about 960 million tonnes annually as by products during industrial, mining, municipal, agricultural and other activities. Out of this, 350 million tonnes are organic waste from industrial and mining sectors, 4.5 million tonnes are hazardous in nature. Globally, the estimated quantity of waste generation is 12 billion tonnes in year 2002 of which 11 billion tonnes were industrial waste, 1.6 billion tonnes were municipal waste. About 19 billion tonnes of solid waste is expected to be generated annually by the year 2025. By year 2047, municipal solid waste generation in India is expected to reach 300 million tonnes and land required for disposal of this waste would be 169.6 as against which only 20.2 that were occupied in year 1997 for management of 48 million tonne. The generation of inorganic industrial waste is estimated around 290 million tonne per annum and hazardous industrial waste is around 4.5 million tonne per annum in India from different industries.

In the study of soil contaminated area in Gujarat, India, **Krishna and Govil (2006)** stated that Surat industrial areas is one of the most polluted industrial area identified by Central Pollution Control Board, New Delhi (India). Twenty five number of soil samples were collected and analysed. Most of the soil samples were collected from near the top surface i.e. 5-15 cm depth to study the anthropogenic sources of pollutants as normally industrial pollutants contaminates the upper layer of the soil (0-40 cm.) An X-ray spectrometer was used along with a 4 KW X-ray generator for the determination presence of of heavy metals (Ba, Cu, Cr, Co, Sr, V and Zn). The result showed that soil in the vicinity of Surat industrial area were found to be significantly contaminated with metals like Cu, Cr, Co, V and Zn, which may give rise to various health hazards.

***Table 2*:** Health effect of hazardouswaste(Dutt et.al.2006)

Hazardous waste	Source	Health effect
Heavy metal		
Arsenic	Mining,non anthropogenic geo-chemical formation	Carcinogenic, cardiac disorders, anaemia
Chromium	Mining, fertilizer industry, battery waste	Carcinogenic, damage to livers and kidneys, chronic obstructive pulmonary diseases, cardiovascular and skeletal disorders
Cadmium	Mining areas, Tanneries	Kidney damage, skin disease, acute tubular damage.
Lead	Lead acid battery smelters	Lead poisoning, neurotoxin, mental impairment in children, damage to brain, kidney and liver.
Manganese	Mining areas	Respiratory disease, neuropsychiatric disorder.
Mercury	Chlor-alkali industries, health care institutes	Mercury poisoning affects human brain, central nervous system, kidneys and liver. High Hg exposure causes vision, speech and hearing impairment. May lead to death.
Nickel	Mining, metal refining	Lung and nasal cancer, damage to gastrointestinal system, cerebral edema, respiratory failure
Hydrocarbons		
Benzene	Petrochemical industries, solvents	Headaches, nausea, leukemia, damage to bone marrow
Vinyl Chloride	Plastics	Carcinogenic (liver and lung cancer), depression of central nervous system, embryo toxic
Pesticide	Insecticides	Cancers, genetic damage, stillbirths, immune system disturbances, embryo damage
Organic chemicals		
Dioxins	Waste incineration, herbicides	Cancer, birth defects, skin disease
PCBs	Fluorescent lights, E-waste, Hydraulic fluid	Skin damage, possibly carcinogenic, gastro-intestinal damage

According to **Narayan, Mazumdar and Bhattacharya (2008**), risk and threats to public health arising due to improper handling, storage and illegal dumping can be reduced if scientific management practices of waste in designated facilities are adopted. Hazardous waste generated in the country based on 18 categories of wastes appearing in the hazardous waste management rules (1989) was around 4.43milliontonne per annum arising from 13011 industries of varies types distributed over 21 states. Out of the total waste estimated, 1.72 million tonnes per annum (39%) was recyclable, 0.18 million TPA (4%) incinerable, and remaining 2.53 million TPA (57%) was disposal in safe landfills (SLF). But according to revised state-wise reports provided in year 2000-2003, total quantity of hazardous waste generated had almost doubled. According to the revised state-wise inventory (2006), total quantity of hazardous waste generated in the country is around 8.26 million TPA while the total number of hazardous waste generating industrial units became 29725. Narayan et.al. (2008)concluded that for minimizing environmental pollution and waste, there are two concepts "Clean Production Technology" and "Cleaner production". The present trend in the developed countries clearly depicts a shift from 'land filling of waste' to clear production technologies.

During study of soil contamination in the area of Patancheru located north of Hyderabad, **Dasaram et.al. (2011)** collected 15 soil samples from an area of about 124 of the Patancheru industrial area. The toxic metal (Ba, Co, Cr, Cu and Ni) in all the soil samples were determined using a wavelength depressive X-ray fluorescence spectrometry. On the basis of experimental results they concluded that soil is the sink for toxic trace metal in Patancheru industrial area and the level of excessive of each metal is varying depending on its chemical characteristics. The soil from residential area is moderately contaminated by Cr, Ni and Pb.

Agrawal and Gupta (2011) have presented the status in India pertaining to generation of hazardous waste and treatment, storage, disposal, facility (TSDF) sites in table.3. The data of hazardous waste generation in Indian states is also given in **Table3**.

The quantity of hazardous waste generation reported was 4.42 million tonne per annum from 373 districts out of 524 in year 2000.

In the area of north western part of Hyderabad, India extending over 200 acres of area and receives on an average 200-300 tonnes solid waste per day. Forty five soil sample were taken to determine elemental composition (As, Cr, Cu, Ni, Pb and Zn) in soil samples with the help of X- ray fluorescence spectrometer and other tests. Analysis of soil samples from 45 sampling points in the surrounding areas of dumpsite showed significant spatial variation of heavy metals (As, Cr, Cu, Ni, Zn and Pb). The results of the study revealed that soil in the downstream and vicinity of

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dumpsite are considerably contaminated by metals with their concentrations beyond threshold values **(Parth et.al. 2011)**.
According to **Das (2012),** the municipal solid waste generation is 39,031 tonnes per day in 59 cities (35 metro cities and 25 states capitals) reported on the basis of survey conducted by Central Pollution Control Board (CPCB) through National Environmental Engineering Research Institute (NEERI) in year 2004-2005. In a similar way, the municipal solid waste generation is about 50,592 tonnes per day, reported on the basis of survey conducted by Central Institute of Plastics Engineering and Technology (CIPET) for the same 59 cities in year 2010-11. As per information

Table 3: Status of Hazardous Waste Generation in India (as on March 2000**)**

State/ UnionTerritory	Total Districts	Districts in which HW units located	Total units	Total HW Generation TPA (tonne per annum)
AndhraPradesh	23	22	501	111098
Assam	23	8	18	166008
Bihar	55	12	42	26578
Chandigarh	1	1	47	305
Delhi	9	9	403	1000
Goa	2	2	25	8742
Gujarat	24	24	2984	430030
Haryana	17	15	309	32559
Himachal Pradesh	12	6	116	2159
Karnataka	27	25	454	103243
Kerala	14	11	133	154722
Maharashtra	33	33	3953	2007846
Madhya Pradesh	61	38	183	198669
Orissa	30	17	163	341144
Jammu & Kashmir	14	5	57	1221
Pondicherry	1	1	15	8893
Punjab	17	15	700	22745
Rajasthan	32	26	332	122307
Tamil Nadu	29	29	1100	401073
Uttar Pradesh	83	65	1036	145786
West Bengal	17	9	440	129826
Total	524	373	13011	4415954

Provided by state pollution control board/ pollution control committee (in between the year 2009-2012), 1, 27,486 tonnes per day municipal solid waste is generated in the country.
According to the report of controller and auditor general's, (CAG - 2012) as per the 10th plan document, India produces 48 million tonne (MT) of urban solid waste annually, with solid waste generation being taken approximately 0.4 kg/capita/day. The director general of health services estimate indicates that 5.4 million tonne of bio medical waste is being generated in country every year, taking a generation rate of 250 gm/capita/day.
The 10th plan document also estimates that around 7.2 million tonne of hazardous waste is being generated in the country. According to Central Pollution Control Board (CPCB), the electronic waste generation is likely to grow and become 0.8 million tonne in the year 2012. There is no estimate available for construction and demolition waste, packaging waste, mining waste, waste from end of life vehicles, tyres and agricultural waste
According to **Tiwana and Singh (2012),** there are number of types of hazardous waste generated from different sectors like industries, medical, municipal and electronic etc. At present most of the solid waste in India is disposed off in unscientific way. Unscientific disposal practices leave waste unattended at the disposal sites which create land pollution, unhygienic condition like odour, release of air borne pathogens. In India, solid waste generation in cities has increased from 6 million tonne in 1947 to 48 million tonne in 1997 and is expected to increase to 300 million tonne per annum by 2047 (Central Pollution Control Board -2000).
According to report of Central Pollution Control Board (June, 2013) on plastic waste management, plastic waste generation is around 5.6 million tonne / annum in year 2011-12. It has also been reported that no authentic estimation is available on total generation of plastic waste in the country. However considering that 70% of total plastic consumption is discarded as waste, approximately 5.6 million tonnes per annum of plastic waste is estimated to be generated in India.
On the basis of above data provided by different departments of government of India, following **Table.4**presents estimate of the current waste generation the different waste (MT per annum).

Table 4: Quantity of different type of waste (million tonne per annum)(According to 10th Plan commission report).

S.No.	Type of waste	Quantity of waste generated (Million tonne per annum)
1	Municipal solid waste	48.0
2	Industrial hazardous waste	7.2
3	E- waste	0.8
4	Bio- medical waste	5.4
5	Plastic waste	5.6
	Total	67.0

The percentage wise distribution of wastes of different categories generated currently in India is presented in **Figure1**.

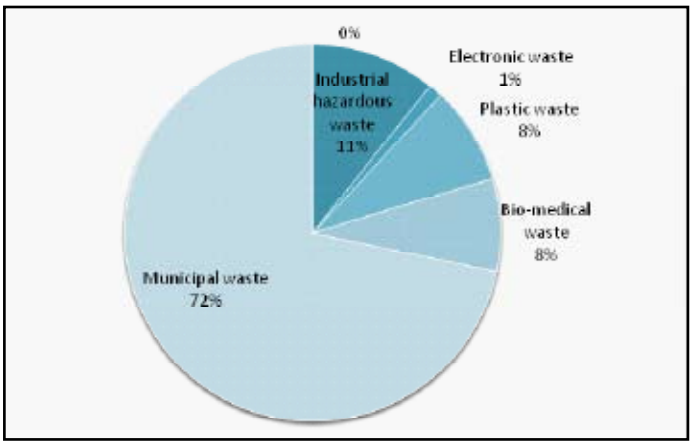

Fig.1:Percentage wise distribution of wastes of different categories in India

III. Contaminated land estimate:

Assuming that major health risk is caused due to industrial hazardous waste disposal practice which is only 11% of the total waste generation.

For the calculation of an annual generation of contaminated land in India, following methodology has been adopted.

1. Determination of no. of hazardous waste generating industries and their waste generation quantity in tonne per annum (TPA) on the basis of data provided by SPCB/CPSB/PCCs of the states.
2. Determination of hazardous waste generation District-wise in each state.
3. Classification of hazardous waste with quantity of waste generation in tonne per annum (TPA)
   - Landfill able
   - Incinerable
   - Recyclable
4. Detailed data collection of landfillable and Incinerable hazardous waste generation state-wise.
5. Convert the quantity of HW to volume (m^3) using the density of 0.85 Tonne/m^3 on the basis of landfill design consideration (eqn.1).

Volume = mass/ density

Volume(m^3)=mass/0.85…….…… (1)

6. Assuming the height of landfill as (a) 5.0 m. and (b) 7.5 m. on the basis of landfill design consideration (eqn.2).

Area of required land (m^2) $= \frac{volume}{height}$…….. (2)

7. Thus with the help of height and volume, a range of land area can be calculated which will be required used for Hazardous waste disposal.
8. Convert the area in hectares(eqn.3).

Area of land (hectares)

$$= \frac{\text{areaofland } (m^2)}{10000} \text{……..} \quad (3)$$

9. Cost of contaminated land can be calculated by multiplying the respective state land rate (crores Rs. per hectare) with land (in hectares) occupied by hazardous waste. This area occupied by hazardous waste, which is essentially unengineered waste disposal in landfills is taken as contaminated land. In addition, there will be possibility of lateral movement of contaminants along the land rendering a larger land area as contaminated. This will depend upon the pathways through which contaminants are transported.

IV. Data Collection

To determine the contaminated land area, following data are required:

Total number of hazardous waste generating industries in India and their state wise distribution.

According to National Inventory of Hazardous Waste Generating Industries & Hazardous Waste Management in India (2009):

In India, There are 36,165 nos. of hazardous waste generating industries, generating 62, 32,507 Metric Tonnes of hazardous wastes every year. The category-wise classification of this quantity is as follows.

- Land Fill able HW- 27, 28,326 TPA
- IncinerableHW -4, 15,794 TPA
- RecyclableHW - 30, 88,387 TPA

It is observed that there the recyclable portion of HW isin the range of 49.55% and is more than other two categories. The land disposable portion and incinerable portion are of the order of 43.78 % and 6.67 % respectively.

Table 5.presents state wise number of hazardous waste generating industries and of the three types of (landfillable, incinerable and recyclable) hazardous waste category (State-wise) obtained from the National Inventory of Hazardous Waste Generating Industries & Hazardous Waste Management in India (2009).

V. Analysis & Discussion

There are two ways to dispose of hazardous waste generated by

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the industries:

1. Safe disposal of hazardous waste in the engineered landfills.
2. Illegally dumped waste in open dumps.

Safe disposal of hazardous waste:

Incineration is appropriate for some hazardous waste because the high temperatures can destroy various synthetic compounds. Other methods include deep burial and deep-well injection. Chemical treatments such as catalysis alter the chemical structure of Hazardous waste, rendering it harmless. Biological treatments use microorganisms, both natural and genetically engineered, to decompose waste. Even then some industrial waste still ends up in local landfills.

In India, treatment, storage, disposal facility (TSDF)is provided to manage the hazardous waste generation from industries. The land used by TSDF to dispose the hazardous waste depends upon the capacity of that treatment plant.

Illegally dumped waste in open dump sites: In the absence of common disposal facilities, the waste generators have been accorded temporary permission to store waste in their premises except in areasserviced by common facilities that have come up in the States of Gujarat, Maharashtra and Andhra Pradesh (where storage period should not exceed for more than 90 days). The lack of common facilities has been a major factor in increasing of the open

Table5: state wise number of hazardous waste generating industries and hazardous waste generation (National Inventory of Hazardous Wastes Generating Industries & Hazardous Waste Management in India (2009) :

S. No.	Name of State/UTs,	No. of HW generating units	Quantity of hazardous waste generation(MTA)		
			Landfillable	Incinerable	Recyclable
1	AndhraPradesh	1739	211442	31660	313217
2	Assam	55	3252	-	7480
3	Bihar	41	3357	9	73
4	Chhattisgarh	174	5277	6897	283213
5	Delhi	1995	3338	1740	203
6	Gujarat	7751	1107128	108622	577037
7	Goa	630	10763	8271	7614
8	Haryana	1419	30452	1429	4919
9	H.P.	1331	35519	2248	4380
10	J.&K.	291	9946	141	6867
11	Jharkhand	435	23135	9813	204236
12	Karnataka	2076	18366	3713	54490
13	Kerala	524	59591	223	23085
14	MadhyaPradesh	1093	34945	5036	127909
15	Maharashtra	4909	568135	152791	847442
16	Manipur	264	-	115	137
17	Meghalaya	43	19	697	6443
18	Mizorum	44	90	Nil	12
19	Nagaland	3	61	Nil	11
20	Orissa	335	74351	4052	18427
21	Punjab	3023	13601	14831	89481
22	Rajasthan	442	165107	23025	84739
23	Tripura	135	0	30	237
24	TamilNadu	2532	157909	11145	89593
25	UttarPradesh	1915	36370	15697	117227
26	Uttaranchal	70	17991	580	11
27	West Bengal	609	120598	12583	126597
28	Daman,Diu, Dadra& NagarHaveli	1937	17219	421	56350
29	Pondicherry	90	132	25	36235
30	Chandigarh	260	232	-	723
	TOTAL	36165	2728326	415794	3088387

dump sites since most of the units in the small and medium sector do not have adequate space within their premises to arrange for storage long periods. Also to save the cost incurred in waste disposal, the unscrupulous industries simply dump their hazardous waste in low lying areas or bury them within or in adjacent areas of the industry. Therefore it is urgently required to make available common hazardous waste treatment and disposal facility in the areas in all the states where HW generating units are operating. Total contaminated land area due to illegal dumping and land utilized for TSDF (state-wise) as obtained from the methodology used is presented in the **Table 6**

Table 6: State-wise contaminated land area (in hectare)

S.No.	Name of state	Hazardous waste earmarked for land disposal (Metric tonne per annum)	Land utilization(hectare)	
			Assuming height of landfill 7.5 meter	Assuming height of landfill 5.0 meter
1	Andhra Pradesh	211442	3.316	4.975
2	Assam	3252	0.051	0.077
3	Bihar	3357	0.052	0.079
4	Chhattisgarh	5277	0.082	0.124
5	Delhi	3338	0.052	0.079
6	Gujarat	1107128	17.366	26.050
7	Gao	10763	0.168	0.253
8	Haryana	30452	0.477	0.717
9	Himachal Pradesh	35519	0.557	0.835
10	Jammu &Kashmir	9946	0.156	0.234
11	Jharkhand	23135	0.362	0.544
12	Karnataka	18366	0.288	0.432
13	Kerala	59591	0.934	1.402
14	Madhya Pradesh	34945	0.548	0.822
15	Maharashtra	568135	8.911	13.367
16	Meghalaya	19	0.000	0.000
17	Mizoram	90	0.001	0.002
18	Nagaland	61	0.001	0.001
19	Odisha	74351	1.166	1.749
20	Punjab	13601	0.213	0.320
21	Rajasthan	165107	2.589	3.885
22	Tripura	0	0.000	0.000
23	Tamilnadu	157909	2.477	3.716
24	Uttar Pradesh	36370	0.570	0.856
25	Uttaranchal	17991	0.282	0.423
26	West Bengal	120598	1.891	2.838
27	Daman, Nagar Haveli	17219	0.270	0.405
28	Pondicherry	132	0.002	0.003
29	Chandigarh	232	0.004	0.005
	TOTAL	2728326	42.786	64.193

Thus approximately **64.193 hectare** land is utilized due to disposal of industrial HW in TSDF facility and illegal dumping of HW disposal. This land is obviously an area which is itself as contaminated and results in further development of contaminated land in its vicinity due to movement of contaminants in surrounding area.**Figure.2** graphically represents state wise contaminated land areas (in hectares).

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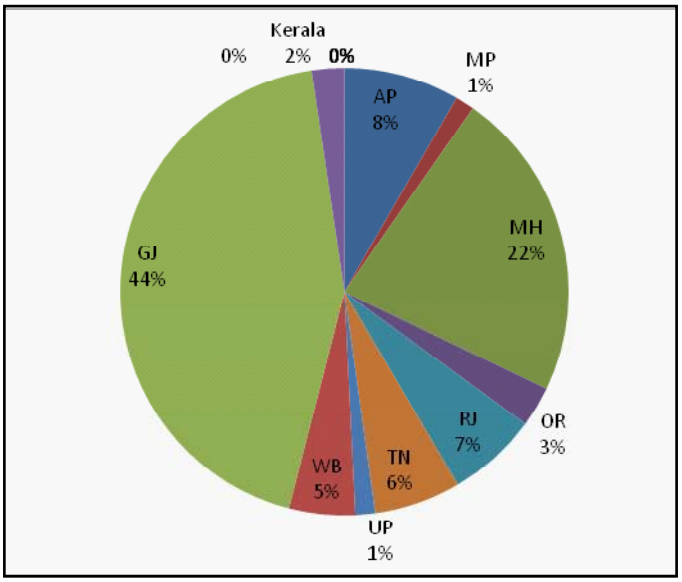

Fig. 2: Percentage wise contaminated land area (hectares) in different states in India

The total cost of land which is being contaminated and utilized in TSDF:

The cost of land in and close to urban area is very high. Further requirement of remediation of such contaminated land adds to the cost of land. Therefore it is useful and important to understand the economics of contaminated land. On one hand, a known contaminated land would have a low cost but disclosed contaminated land would have a very high cost. Because of the health risk and remediation cost. Even assuming rates of normal land, the cost estimates would give the idea of land costs involved.

The cost estimation is done only for those states in which contaminated land area is more than 0.5 hectare.

These states are Gujarat, Maharashtra, Andhra Pradesh, Rajasthan, Tamilnadu, West Bengal, Kerala, Uttar Pradesh, Madhya Pradesh and Karnataka. The cost estimation is calculated by multiplying the contaminated land area (in hectares) with the rate of land (million rupees per hectare) in for each state. Their individualdetail are presented in the **Table.7.**

Total cost of land rendered contaminated in the major part of hazardous waste generating state is (approx.) =**10400.3 to 45314.7 million rupees (one thousand crores to 4.5 thousand crores rupees) every year.**

National Inventory of Hazardous Waste Generating Industries & Hazardous Waste Management in India (2009), report stated that Common Treatment, Storage and Disposal Facilities (TSDF) are developed for the disposal of land disposable HW at 22 different places in 10 States only namelyGujarat, Maharashtra, Uttar Pradesh, Andhra Pradesh, Himachal Pradesh, MadhyaPradesh, West Bengal, Punjab, Rajasthan and Tamil Nadu. Total disposal capacity ofthese facilities, is 15, 00,568 TPA which

Table 7: State-wise contaminated land cost (in million rupees)

S.No.	Name of state	Land occupying HW area(hectare)	Rate of land (million rupees @hectare)*		COST OF LAND (million rupees)	
			minimum	maximum	minimum	Maximum
1	Gujarat	26.050	110.0	302.5	2865.5	7880.1
2	Maharashtra	13.367	257.5	2000.0	3442.2	26735.7
3	Andhra Pradesh	4.975	220.0	397.5	1094.5	1977.6
4	Rajasthan	3.885	220.0	475.0	854.6	1845.2
5	Tamilnadu	3.716	260.0	612.5	966.0	2275.7
6	West Bengal	2.838	122.5	530.0	347.7	1504.5
7	Kerala	1.402	340.0	1022.5	476.7	1433.7
8	Uttar Pradesh	0.856	105.0	230.0	89.9	196.8
9	Madhya Pradesh	0.822	87.5	812.5	72.0	668.1
10	Karnataka	0.432	442.5	1845.0	191.2	797.3
	TOTAL	58.343				4.7

*{ http://india.gov.in/topics/housing/ews-housing,www.dolr.nic.in,www.igrmaharashtra.gov.in, http://gicl-gicl.blogspot.in,http://www.rajstamps.gov.in/sarthi/web/jsp/dlcratesmain.jsp,www.wbrsrsa.org ,**Chakravorty (2012)**}

Figure 3. Graphically presents cost of contaminated land being generated in different states in India.

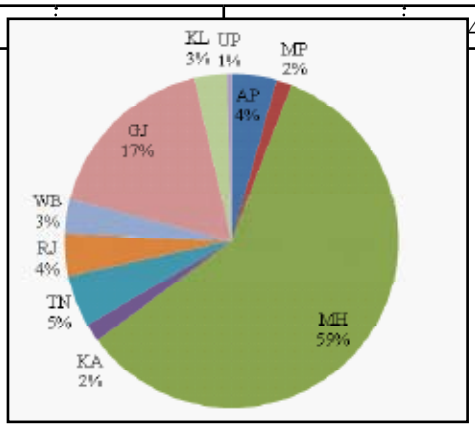

Figure 3: percentage wise cost (million rupees**)** of contaminated

land area in different states in India.

is much less than the present generation of 27, 28,326 TPA of land-disposable HW.The deficit of TSDF capacity is 12, 27,758 TPA. It is obvious that the additional TSDF to the tune of 15, 00,000 TPA must be developed to accommodate the present and future quantities of land disposable HW.This contaminated land area is in the range of **42.8 to 64.2 Hectare.**

As per the information provided by the Central Pollution Control Board (CPCB-2012), the amount of hazardous waste generated in the country is about 7.2 million tonne per annum. Maharashtra (22.84%), Gujarat (22.68%) and Andhra Pradesh (13.75%) are the top three hazardous waste generating states in the country followed by Rajasthan, Tamil Nadu, Madhya Pradesh and Chhattisgarh. These seven states together are generating about 82% of the country's total hazardous waste.

Cost of contaminated land area: Cost of contaminated land can be calculated by multiplying the land rate(crores per hectare) with area of land (in hectares) in contaminated land zone.This gives an idea about total contaminated land area and cost of such type of land(not including remediation cost).Thus every year a growing land area is being rendered contaminated as a health risk in highly industrialized state like Gujarat, Maharashtra, West Bengal, Andhra Pradesh, Madhya Pradesh, Delhi, Kerala, Uttar Pradesh, Rajasthan, Tamilnadu and Karnataka.

VI. Conclusion

On the basis of the study carried out following conclusion can be drawn:

- Generation of hazardous waste is approximately 2.73 million tonne per year while the official capacity to treat and dispose off is only 1.5 million tonne per year. **Hence there is a need to create additional facility for treat and dispose of around 1.23 Million tonnes per year**. Unregistered hazardous waste producing industries and the amount in India is any body's guess.
- The performance of the states Gujarat, Maharashtra, Tamilnadu, West Bengal for safe disposal and treatment of their HW is not good and lot of area become contaminated every year due to open dump sites.
- Cost of land which is utilized for Treatment, Storage and Disposal Facility (TSDF)and open dumping (approx.) varies from **10400.3 to 45314.7 million rupees (one thousands crore to 4.5 thousand crore rupees).**

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