Report on waste dump sites around Bangalore

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Abstract

The present work aims at identifying, locating and quantifying the industrial and domestic waste dump sites located in and around Bangalore urban and rural districts of Karnataka state, India. Bangalore has a population of 6 million and has more than 2000 industries working at various industrial estates and other locations around the city. It was reported that about 1500 tons of municipal waste per day is being generated from Bangalore city. Studies reveal that there is no scientific treatment and disposal facility for scientific management of the waste generated. The waste from industries and community areas is disposed in an unscientific manner at several open dump sites across the city. There are more than 60 dump sites consisting of both municipal and industrial waste existing in and around Bangalore city; the locations are totally unhygienic. Based on the experience gained from field visits, physical observation of the waste disposed, quantity and nature of the waste disposed, each site was given with a grading based on polluting potential of the site. For selected sites, ground water samples were collected from nearby surface or bore wells and analysed for possible contamination. From the study, it was found that the site needed immediate attention and comes under severe impact category of 27 numbers and that of medium and low impact are 18 and 6 numbers, respectively. The disposal sites have got tremendous potential of spreading the epidemics/diseases to the people living in their immediate vicinity and at nearby places.

1. Introduction

Generation of waste either in the form of solid waste or liquid waste is an inevitable component of the industrial and community activity. Nowadays, the waste generated is so complex in nature and consists of varied chemical or biological constituents. The waste generated is classified as hazardous waste and non-hazardous waste based on the chemical composition or reactive characteristics of the waste and/or detrimental potential towards man and environment. The waste disposed on open land by the community or industries forms an illegal or wild waste dump site. Illegal dumping of waste is everyone's problem; it can be harmful to wildlife, plants and water, and damage the surrounding community and state economy. Open dumping is a long-standing problem in this country and others, where certain locations become routine sites and dump piles attract additional dumping. It is a very common practise to dispose the waste generated by the community and the industries on to the land, into sea or into low lying area. The sites may consist of fully or the partially industrial or domestic waste.

The state of Karnataka is one of the fast developing states in India. Bangalore is among the major cities with high pace of development in all sectors of development like; education, instrumentation and information technology, medical facility, industrialisation and urbanisation. The state has a population of about 60 million out of which Bangalore is having 6 million population (Source: Census of India). It was reported that about 1500 tons of municipal waste per day is being generated from Bangalore city (IUEIP, 1999). Each day about 500–600 tons of municipal waste generated from residential areas, city market and hotels of the city is being collected and transported to Karnataka Compost

Development Corporation (KCDC), located at Hosur road, Bangalore. The waste collected is treated and converted into useful manure by the process of mechanical composting and vermin composting. The manure produced by this process is sold to public and farmers at a cost of three thousand rupees per ton of waste. After successful and profitable running of composting unit, there was an attempt by the same corporation office to develop another composting unit near Magadi village. But, inappropriate location of the unit had led to public agitation and subsequent closure of the unit. Other than the wastes collected by KCDC, the rest of the waste was disposed at several open sites. Open dump sites predominate in all districts of the state, and in the absence of regulatory controls, hazardous wastes continue to find their way into such sites. Many sites are causing subsoil contamination and water pollution; there are no special measures to prevent contamination of soil and water resources.

1.1. Methodology

Waste disposed sites must be assessed to determine the extent of contamination before cleanup is initiated. Site assessment follows a common procedure that is divided into three phases. Site assessment is initiated whenever the existence of hazardous waste site is suspected, which may include a leak in the under ground storage tank, the discovery of hazardous chemicals in drinking water supply, a high incidence of localized illness, or a routine property transfer. Preliminary assessment, remedial investigations and feasibility study follow the format of the general site assessment phases (Richard, 1997).

The three site assessment phases are Phases-I, -II and -III; each builds upon the previous phase with more extensive information. A Phase-I assessment called as initial assessment study or preliminary assessment study focuses on "soft" or non-scientific information and is analogous to a background search. Phase-I studies involve paper research including a chemical inventory evaluation, interviews with current and former personnel and neighbours, and regulatory agency record searches and interviews. Title searches and reviews of historical ownership are also necessary under liability clauses. Other records that are often reviewed include aerial photographs, national agency permits and violations, zoning maps, tax records, fire records, and newspaper articles.

The on-site inspection and personnel interviews provide information and perspectives that cannot be obtained through records and searches. Often retirees, neighbours, and employees of 20+ years are able to relay information on the past disposal practises and the location of the buried wastes. A 'walk-through' of the site can often provide clues of improper waste disposal. Signs such as stained soil, an unlined pit, or concrete pads associated with an abandoned fuel farm, solvent storage area, pesticide mixing/loading zone, or gasoline station may provide the evidence necessary to initiate Phase-II study. Phase-I reports do not certify that the site is free of contamination, but they provide a basis for further study or investigation.

If the suspicions that were first raised to initiate the site assessment are confirmed in the Phase-I evaluation, a Phase-II study is warranted to confirm or deny the presence of the hazardous wastes at the site. A Phase-II study includes finalising any record searches that were not completed in the Phase-I assessment. A detailed evaluation of pathways and potential receptors has begun, which may include an analysis of the subsurface by a hydrologist to assess ground water flow directions and travel times to drinking water wells or other receptors. If ecological damage is evident, a biologist may assess critical habitat or the need for ecological risk assessment.

Phase-II assessments often involve increased sampling efforts. Based on where the contamination is expected, surface soil "grab samples" (random samples collected without any guidance from prior knowledge), soil cores, surface water samples, and water samples are collected after the installation of the monitoring wells. There are no firm rules on the degree to which sampling is conducted during a Phase-II assessment; sampling intensity evolves on an ad hoc basis through negotiations among the site owners, their consultants, and state regulators. If the Phase-II studies show that the site is contaminated, a Phase-III study is initiated. The purpose of a Phase-III investigation is to detail the extent of contamination in terms of the area, volume and contaminant concentrations. Depending on the source characteristics, age of the site, and predominant pathways, the source and adjacent areas (soils, subsurface, and/or ground water) may be sampled extensively. With appropriate sampling designs, contaminant concentrations data over depth and area provide sufficient information to assess the site hazard (i.e., the need for site cleanup) and provide criteria for the design of remedial process (Richard, 1997).

Based on the experience gained from field visits, physical observation of the waste disposed, quantity and nature of the waste disposed, each site was given with grading based on polluting potential of the site. For selected sites, water samples were collected from nearby surface or bore wells and analysed for possible contamination.

From the study, it was observed that not much importance is given for segregation, handling and disposal of waste both by the general community and industrial units. There is no specific scientific methodology suggested or adopted for collection and disposal of household waste generated by a family or from the industrial units. By understanding the importance of the waste management on community health and economics of the state, the state government made attempts to develop engineered landfill facility for scientific treatment and disposal of domestic waste generated by the civil community and industrial hazardous waste generated by all sectors of industries in the state. The main objective of this study is to deal with the following issues: to list all dump sites and quantify impact assessment of each site, risk assessment and proposals for the remediation activities. The scope of the present work is to mainly deal with identifying, locating, quantifying and documentation of all illegal or open waste dump sites of both municipal and industrial waste existing in and around Bangalore urban and rural districts. This paper provides a clear picture of the location of waste sites, waste spread area and highlights the estimated quantity of both domestic and industrial waste disposed. The present study aims at documentation of waste disposal sites in and around Bangalore districts.

1.2. Background

The state government along with Karnataka State Pollution Control Board (KSPCB) is in the process of developing treatment storage and disposal facility for scientific handling and disposal of waste generated by the general community and industries. The facility includes design and development of engineered landfill facilities to dispose domestic waste and industrial hazardous waste in landfills for the entire state. For effective design and efficient management of the facility, clear data base on the waste quality, quantity, generation rate from community and industries. The state is planning to have documentation of all waste disposal sites that are present across the state and the details of quantity, quality waste disposed and location of the disposal site with access to the site. Age of the site, soil condition, land use pattern, ground water details and its quality information are very much essential for optimal design of the treatment disposal facility. The gathering of details of sites plays a vital role in the estimation of total cost of the project as it involves cost for segregation of hazardous and non-hazardous waste and transportation to respective treatment disposal facility, and also incurs cost of remediation activities to be planned, executed for illegal/open waste disposal sites. Hence, it is important to identify all sites existing across the state and characterise the waste to the extent possible.

2. Study area

2.1. Description of the study area

The Bangalore urban and rural districts are located in south eastern part of Karnataka state between 12°15′N and 13°31′ latitude and 77°59′E and 77°59′ longitude at about 954 m above mean sea level. The climate of the city is seasonally dry tropical savannah with four seasons. The dry season with clear bright weather prevails from December to February, the summer season from March to May followed by the south west monsoon from June to September. October to November constitute the post monsoon period. The temperature ranges between 33 °C in April and 14 °C in January. Bangalore district is treated as climatically well favoured district in south deccan of peninsular India. The marked thunderstorm activity with occasional hailstorm and squalls is during April to May; September to October is also typical. Other important features are the predominant low clouding and more or less steady temperatures with small diurnal variations during the whole monsoon season and the early morning dew and mist or fog during the months of October to February.

The city has historical citation and has shown well documented growth in all sectors of development like education, medicine, industry, information technology and similar fields. The city has witnessed rapid growth in industries and population for the past two decades. The total population of the state being 60 million and the population of Bangalore city alone being 6 million (Source: Census of India, 2001). Bangalore urban and rural districts have more than 60% of industries established in its land area out of total industries existing in the state (Source: KSPCB, 2001). More than 250 health care establishments and nearly about 450 small scale industries are located in the city. Bangalore urban and rural districts have got 475 and 91 hazardous waste generating industries, respectively. Whereas, more than 1000 hazardous waste generating industries are existing in the state. The industrial establishments and their distribution in the state are shown in Figs. 1 and 2.

The mean annual rainfall is around 950 mm, and the number of rainy days is about 57. June to September is the principal rainy season. The annual rainfall shows

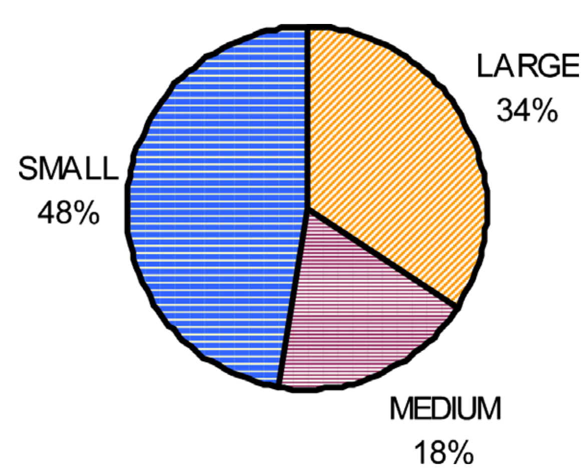

Fig. 1. Distribution of large, medium and small-scale industries.

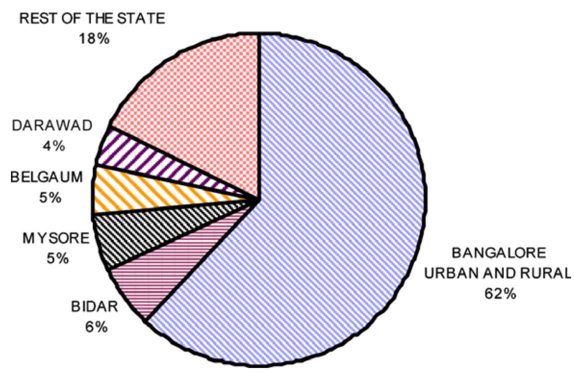

Fig. 2. Distribution of hazardous waste generating industries.

two maxima and two minima. The principal maximum is in September and the secondary is in May. Bangalore receives 54% of the total annual rainfall in southwest monsoon period with a rainfall of 496 mm and 34 rainy days. The surface winds over Bangalore have fairly clear cut seasonal character with easterly components predominating in one period and westerly components in the other.

2.2. Demography

Table 10 shows the population of the state for the past five years. Karnataka state population is about 60 million (Source: Census of India, 2001). There are about 6 million people residing in the city of Bangalore. The population consists of varied groups of people with different religions and of various languages. People belonging to more than five religions with seven major languages are residing in this locality.

2.3. Topography

The eastern part of the study area is dominated by plain area with slightly undulated terrain, whereas the western and southern parts are dominated with hilly terrain with heavy undulations. The total district area forms the catchment area for two river basins; Cauvery river basin and Pennar river basin. The district has a reservoir for supplying drinking water to the city, population which is located on western part of the district. Bangalore is the capital city of Karnataka state and is the centre of attraction for all issues related to public, like; education, industry, parliamentary, judiciary, and administrative head offices. The city has good road and railway network connecting five capital cities of the surrounding states. It also has an international airport and domestic airports for its infrastructure. The city has got major establishments related to software industry and also computer hardware industries. Nearly about 125 multinational companies belonging to USA, UK, Japan and other countries function at Bangalore (Source; Department of IT, GoK).

3. Methodology adopted

The identification, quantification and assessment for all waste dump sites were undertaken as follows.

3.1. Identification of sites

Information related to all waste disposal sites were collected from all possible sources like; government agencies, pollution control board offices, regional offices, newspaper cutting, local news channels, information from the local people, etc. The collected topography maps related to area located the dump site and marked a radius of 500 m around the site on the map. The on-site inspection and personnel interviews provided vital information on waste type and age of the dump site, with possible source of waste.

3.2. Description of the site

After identifying the dump site, if the site was found to possess industrial waste, then each site details, such as waste quantity, quality, age of dump site, waste spread area, nearby water bodies (both surface and ground water), important building or monuments and historical places were recorded. Socio economic data were also collected for the respective site.

3.3. Quantification of the waste

Waste quantity was calculated by physically measuring the waste spread area and the depth of waste disposed. By knowing the volume of waste and approximate density, the quantity of the waste was evolved. In case of mixture of industrial and domestic waste, waste quantity was calculated according to their individual volume of waste as approximated or calculated.

3.4. Assessment of the site

Grab samples of waste were collected and analysed for their possible chemical composition; this was done only for selected sites because of the resource constraint and time limitations. Soil samples from the waste dump site (just below the waste pile), surface and ground water samples from water bodies located within 500 m from the location of the dump site were collected and tested at the laboratory. Standard procedures were followed in collecting and testing of the wastes and water samples from waste dump sites.

3.5. Sampling procedure

By selecting the existing surface or ground water sources/wells around the site located within 500 m radius around the dump site. Minimum of four water samples around the dump site in four directions was collected. Grab samples were taken for solid waste samples disposed on land.

3.6. Testing parameters

Soil and water samples collected were tested for their possible contamination. Soil samples were analysed for possible metal ion concentrations or the major pollutants which can be anticipated based on the industrial activity in the surrounding area. The water samples collected were analysed for various parameters with drinking water standards as the reference.

3.7. Plans for rehabilitation works

After detailed analysis of the site condition and the type of waste disposed. The sites will be prioritised and ranked based on severity of the problem, in case the sites require specific remedial measures, the same will be addressed as the case may be in Phase-II operations. Based on the intensity of pollution and importance of the site, detailed rehabilitation works as required in each case will be proposed. Specific action plans and recommendations for rehabilitation will be suggested. This part of the work will be addressed after successful completion of the first phase of inventory and detailed studies of the dump sites.

Table 1
Municipal waste generation rate in Bangalore

Source	Quantity (t/day)	Composition (% by weight)
Residential	780	54
Markets	210	14
Hotels and restaurants	290	20
Commercial premises	85	6
Slums	20	1
Hospitals	25	2
Street sweepings, parks, open places	40	3

4. Waste generation

4.1. Waste composition

Tables 1 and 2 show the municipal waste generation and physical composition of waste generated by civil community of Bangalore. It can be observed from Table 1 that the waste generated by the residents is about 54% and is the highest among other sources. Whereas the waste generated from hospitals, hotels and restaurants is about 20%, and markets contribute about 14% of the total waste generated by community. Table 2 shows the waste composition; it is clear that the waste consists of 72% putricible waste, 11% paper, 6% plastic, 1.4% glass and about 1% hazardous waste. The hazardous waste in municipal waste may consist of household hazardous waste like; light tube, batteries, pesticides, medicine/drugs and similar such items.

4.2. Municipal solid waste

A recent survey of municipal solid waste revealed that approximately 1450 tons of municipal solid waste, excluding industrial waste and construction demolition waste, is produced each day in the city of Bangalore (IUEIP, 1999). This equates to an average waste generation rate per capita of 0.27 kg/day. The major constituents of municipal solid waste in Bangalore are organic matter/putrescible waste. Typically, this comprises 74% of the municipal waste stream. The proportion of organic matter/putrescible waste is source-dependent ranging from approximately 16% of waste from commercial premises to 90% for market waste and street sweeping waste.

4.3. Biomedical waste

Approximately 25 tons of waste is generated per day by healthcare institutions in Bangalore (KSPCB, 2001).

Table 2
Physical composition of municipal waste in Bangalore

Waste type	Composition (% by weight)						
	Residential	Commercial	Hotels and restaurants	Markets	Slums	Street sweepings	All sources
Putrescible	71.5	15.6	76.0	90	29.9	90	72.0
Paper	8.4	54.6	17.0	3	2.5	2	11.6
Plastics	6.9	16.6	2.0	7	1.7	3	6.2
Glass	2.3	0.7	0.2	–	8.4	–	1.4
Metals	0.3	0.4	0.3	–	0.2	–	0.2
Dust and ash	8.1	8.2	4.0	–	56.7	5	6.5
Clothes, rags and rubber	1.3	4.0	0.4		0.5	–	1.0
Hazardous	1.2	–		–	–	–	0.9

The composition of biomedical waste in Bangalore, kitchen and office wastes and other uninfected and non-hazardous wastes comprises a significant proportion of waste generated by healthcare institutions (about 40–70% by weight); Infected and potentially infected waste (including body parts and tissue) also constitutes a significant proportion of the biomedical waste (about 22–60% by weight). While recyclables constitute a relatively major component of waste from healthcare institutions (about 15–25% by weight), much of it is infected or potentially infected and must be handled and treated separately and accordingly. Hazardous chemicals and drugs form only a minor proportion of biomedical waste.

4.4. Hazardous industrial waste

Data reveal that more than 1000 industries in the state are registered as industries generating hazardous waste (KSPCB, 2001). These industries generate almost 80,000 tons of hazardous waste per year. The hazardous waste is presently temporarily stored or stockpiled within industrial premises. The emissions from unscientific disposal of solid/liquid hazardous waste from industries contain most dangerous heavy metals, acids, oil emulsions, toxic wastes or infectious waste which can spread dreaded diseases to man or damage the environment. Fig. 1 shows information on distribution of small, medium and large scale industries in the state. Fig. 2 shows the distribution of hazardous waste generating industries.

4.5. Present practice

As on today, the state does not have any scientific treatment and disposal facility to treat and dispose the waste generated by its civil community or the industries. Both domestic waste and industrial waste are being disposed on open land, or low lying area or into the sea. The waste disposed leads to generation of leachate which contaminates the subsoil, surface and ground water resources.

5. Results and discussion

During the study period, in study area, a visit was made to all the waste disposal sites and a survey conducted for type of the waste being disposed at all sites; photographs were taken for all sites. The dump site details, such as location of the site, waste spread area, type of waste (domestic/industrial), nature of waste (solid/semi solid/liquid waste), nearby industrial area, numbers of years of disposal and quantity of waste being dumped, were collected from the local people/villagers. The waste spread area was measured or approximated as the case may be. The volume of the waste was calculated/approximated as the case permits and thereby the quantity of the waste was assessed. The hazardous waste generation in the state is about 80,000 tons per year. Municipal waste generated in Bangalore city alone is about 0.5 million tons per year. There is accumulated quantity of about 5000–6000 tons of rejects from KCDC, which consists of glass, rubber, and ferrous material waste. This waste may be considered as industrial waste and disposed at Treatment Storage and Disposal Facility (TSDF). From the study, it was found that sites which need immediate attention and come under severe impact category are 27 numbers and that of medium and low impact are 18 and 6 numbers, respectively. From the field data collected, the industrial waste disposed at sites as on date will be about 25,000 tons and that of domestic waste is about 60,000 tons. With present rate of generation, the industrial waste present on sites will be of one year and that of domestic waste is of two months. The details of dump sites and location

Table 3
Waste dump sites around Bangalore–Mysore road

Site no.	Type of waste	Waste spread area (acres)	IW (tons)	MW (tons)	Risk factor	Remarks
11	Industrial and domestic wastes including waste oil	3	150	700	S	It was found that the oil waste spread over 25 m^2 and domestic waste was burning openly
12	Industrial/domestic waste	3	75	100	S	Stone polishing powder and domestic waste
13	Industrial/domestic waste	3	650	850	S	Since 6 years the waste being dumped at this place
14	Domestic waste	1.5	0	200	M	Domestic waste was burning
15	Domestic waste	1.5	0	200	M	Domestic waste was spread over agricultural land and it was burning
16	Domestic waste	0.5	0	100	L	Villagers are against disposing of waste in their lands
17	Industrial waste	0.2	25	0	S	Wastes includes oil, glass wool
18	Packaging waste	0.2	0	75	L	Stored in private land with compound walls
19	Domestic waste	2	0	250	L	Used as land filling material

Note: IW, industrial waste; MW, municipal waste.

Table 4
Waste dump sites around Bangalore–Tumkur road

Site no.	Type of waste	Waste spread area	IW (tons)	MW (tons)	Risk factor	Remarks
21	Industrial/domestic waste	20 acres	3500	50	S	Foundry, ceramic, oil, rubber, glass wool, stone polishing powder, sludge along with domestic and building construction wastes. Coir waste (about 25 ft height)
22	Construction/industrial waste	2.5 acres	50	700	S	Disposed into surface water tank (about 25 ft height)
23	Industrial/domestic waste	50 sq.ft	10	5	M	Rubber, clothes, glass wool and building construction waste
24	Industrial waste	40 sq.ft	1000	0	S	Sludge disposed on land
25	Industrial waste	1 acres	400	0	S	Industrial sludge, rubber and other mixtures
26	Industrial waste	1.5 acres	550	0	S	Industrial waste mixtures
27	Domestic and construction waste	2 acres	0	250	M	Waste spread near a surface water tank
28	Domestic waste	20 acres	0	1250	S	Spread over on agricultural land
29	Domestic waste	6 acres	0	4250	S	Legal site operated by GoK. Composting of domestic wastes by mechanical and vermi compositing system but stopped due to villagers opposition

Table 5
Waste dump sites around Bangalore–Hosur–Bannergatta road

Site no.	Type of waste	Waste spread area	IW (tons)	MW (tons)	Risk factor	Remarks
31	Domestic waste	22 acres	0	60,000	L	Legal site maintained by GoK for compositing of waste
32	Domestic/Industrial waste	60 sq.ft	25	100	M	Disposed by the side of the main road
33	Industrial/domestic/bio-medical/ construction waste	9 acres	1500	1500	S	Bio-medical, foundry, glass pieces, tube lights, oil, sludge, chemicals, stone polishing powder, fibrous waste, electronic waste, rubber, metal wastes and domestic wastes
34	Industrial/domestic waste	6 acres	500	750	S	Sludge, chemicals, stone crushed powder, fibrous waste, electronic waste, rubber, metal wastes and domestic wastes
35	Industrial/domestic waste	4.5 acres	500	1000	M	Stone polished powder
36	Industrial/domestic waste	1.5 acres	150	150	S	Disposed near a surface water tank

Table 6
Waste dump sites around Bangalore–old Madras road–Hosakote road

Site no.	Type of waste	Waste spread area	IW (tons)	MW (tons)	Risk factor	Remarks
41	Industrial waste	1500 sq.ft	200	0	S	Mica and other insulating materials
42	Domestic waste	25 sq.ft	0	50	M	Vegetable waste
43	Domestic waste	50 sq.ft	0	100	M	Waste disposed near a surface water tank
44	Industrial/domestic waste	250 sq.ft	250	600	S	oil sludge was packed in 60–70 bags along with other industrial and domestic wastes
45	Industrial waste	4 acres	3000	0	S	Stone crushed/polished powder, slabs.
46	Industrial waste	1 acres	300	0	L	Granite stones, stone polished powder, slabs.
47	Industrial waste	100 sq.ft	75	0	M	Stone polishing powder dumped by the sides of the road
48	Domestic waste	0.5 acres	0	350	S	Domestic waste along with tube lights
49	Domestic waste	5 acre	0	3000	S	Domestic waste dumped on private land
410	Domestic waste	2 acre	0	15,000	S	Waste was dumped over agricultural land

are given in Tables 3–8. Fig. 3 shows location of waste disposal sites around the districts. The waste disposal site locations shown are indicated with approximate positions, as the map shown is not to scale.

Table 9 shows the variation of different parameters analysed for ground water quality in the immediate vicinity of the waste disposal site. Here, water quality results of only one site are shown for the better understanding of the procedure followed by us in preliminary impact assessment of the waste disposal sites. The variation of calcium, potassium, iron, sodium, chlorine, carbonate magnesium, bicarbonate, sulphate, nitrate and fluoride ion concentrations along with biological oxygen demand (BOD), chemical oxygen demand (COD) and total hardness (TH) for the samples collected from bore well number A, B, C, D, E and F listed is in Table 9.

Table 7
Waste dump sites on Bangalore–Hyderabad Road–Doddaballapur road

Site no.	Type of waste	Waste spread area (acres)	IW (tons)	MW (tons)	Risk factor	Remarks
51	Construction waste	0.5	0	100	M	Disposed near a surface water tank
52	Construction/domestic waste	1	0	500	M	Disposed near a surface water tank
53	Domestic and industrial waste	1	5	10	M	Disposed near a surface water tank
54	Industrial waste	5	75	0	S	Dumped electronic waste, sludge, tube lights, stone crushed powder, oil and other domestic wastes spread over eucalyptus plantation area
55	Industrial waste	2	125	0	S	Glass wool, electrical wire, tube lights, chemicals, sludge, bottles and other domestic waste burnt in the private agricultural land
56	Industrial/domestic waste	2	25	100	S	Rubber, PCB, glass wool, electrical cables and other domestic waste burning in the agricultural land
57	Domestic waste	3	0	150	S	Domestic waste was disposed in waste land
58	Domestic waste	1	0	150	M	Waste was disposed in by the side of the road

Table 8
Waste dump sites around Bangalore–Air port road

Site no.	Type of waste	Waste spread area	IW (tons)	MW (tons)	Risk factor	Remarks
61	Domestic waste/construction waste	3 acres	0	85	M	Disposed on open land
62	Industrial waste	50 sq.ft	10	0	S	Oil, rubber, shoes and other industrial wastes disposed on private land
63	Industrial waste	1 acre	400	0	M	Foundry waste
64	Construction waste	1 acre	0	250	L	Disposed on low lying area
65	Industrial waste	5 acre	250	0	S	Plastic and glass wool were burning
66	Industrial/domestic/construction waste	1 acre	50	200	S	Disposed near a surface water tank
67	Domestic waste/construction waste	2 acres	0	85	M	Disposed on open land
68	Domestic waste/construction waste	3 acres	0	900	M	Disposed on open land
69	Domestic waste/construction waste	30 sq.ft	0	75	M	Disposed on sides of the road

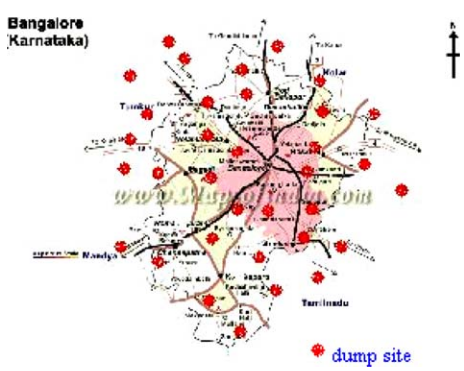

Fig. 3. Location of waste disposal sites around Bangalore district.

It can be observed that calcium ion concentration variation alters from 100 to 300 mg/l. Sample from bore well C has shown higher concentration of 300 mg/l whereas bore wells B and D have about 100 mg/l of calcium ion concentration. The total hardness variation alters from 100 to 1300 mg/l. Sample from bore well A has shown higher concentration of 1320 mg/l, whereas bore wells C and E have shown about 100 mg/l of total hardness of water. Magnesium ion concentration varies from 30 to 180 mg/l. Sample from bore well E has shown higher concentration (180 mg/l) of magnesium ion concentration. Bicarbonate ion concentration variation alters from 200 to 400 mg/l. Sample from bore well E has shown about 200 mg/l of bicarbonate ion concentration. Sulphate ion concentration variation alters from 50 to 300 mg/l. Sample from bore well E has shown higher concentration of 300 mg/l, whereas bore wells B and D have shown about 50 mg/l of sulphate ion concentration (see Table 10).

Chloride ion concentration variation alters from 200 to 800 mg/l. Sample from bore wells C and E has shown higher concentration of 800 mg/l, whereas bore wells B and D have shown about 200 mg/l of chloride ion concentration. Comparatively, the water samples collected and tested from different bore wells, it was observed that almost all the tested samples revealed higher chloride ion concentrations. From this, we can conclude that

Table 9
Details of water quality and ground water analysis

Sample no.	Ca (mg/l)	Total hardness (mg/l)	Mg (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)
A	296	1320	145	Nil	396.9	635.6	139.5
B	105.6	492	57	Nil	274.4	238	43
C	328	130.4	121	Nil	249.9	803	88.2
D	96	376	34	9.6	225.6	176.4	53.3
E	289.6	144.8	181	Nil	220.5	789.6	295
F	270	952	69	Nil	333.2	565.6	142
Sample no.	NO_3 (mg/l)	K (mg/l)	F (mg/l)	pH	EC	BOD (mg/l)	COD (mg/l)
A	114.3	24	0.1	7.8	3050	7.9	81.3
B	29.8	17	0.1	8.1	1210	7.9	70.0
C	61	13.8	0.2	7.8	3000	7.6	85.9
D	83	6.2	0.1	8.5	1050	7.6	85.9
E	87.3	8	0.2	7.8	3100	7.8	89.0
F	24.9	4.6	0.1	7.8	2300	7.9	77.4

Table 10
Population of Karnataka district 1999–2003 (in thousands)

Districts	1999	2000	2001	2002	2003
Bangalore urban	6521	6770	7028	7297	7596
Bangalore rural	1880	1908	1963	1965	1994
Bagalkote	1652	1687	1724	1760	1798
Belgaum	4145	4221	4299	4378	4459
Bellary	2051	2107	2165	2225	2286
Bidar	1544	1584	1626	1669	1713
Bijapur	1821	1860	1900	1942	1984
Chamarajanagara	1033	1053	1074	1096	1117
Chikmagular	1115	1128	1142	1155	1168
Chitradurga	1552	1586	1620	1655	1691
Dakishna Kannada	1850	1881	1911	1943	1975
Davangere	1888	1953	1983	2033	2084
Dharwad	1592	1622	1652	1683	1714
Gadag	997	1016	1035	1054	1074
Gulbarga	3116	3190	3266	3344	3424
Hassa	1789	1819	1860	1882	1914
Haveri	1477	1504	1533	1563	1593
Kodagu	509	511	514	516	519
Kolar	2521	2562	2604	2646	2689
Koppal	1203	1238	1273	1310	1348
Mandya	1856	1859	1925	1955	1987
Mysore	2735	2799	2864	2930	2999
Raichur	1713	1765	1818	1873	1930
Shimoga	1641	1667	1692	1719	1745
Tumkur	2649	2697	2746	2796	2847
Udupi	1175	1190	1206	1222	1239
Uttar Kannada	1359	1378	1397	1416	1435
Karnataka	*53395*	*54574*	*55784*	*57026*	*58302*

Source. Census of India 2001.

the industrial solid and liquid wastes disposed are having higher salt solutions.

Nitrate ion concentration variation alters from 25 to 120 mg/l. Sample from bore well A has shown higher concentration of 120 mg/l, whereas bore wells B and F have shown about 20 mg/l of nitrate ion concentration. Potassium ion concentration variation alters from 5 to 25 mg/l. Sample from bore well A has shown higher concentration of 25 mg/l, whereas bore well F has shown about 5 mg/l of potassium ion concentration.

It was observed that hydrogen ion concentration variation alters from 7.5 to 8.5. Sample from bore well D has shown highest pH value of 8.5, whereas other bore wells have about 7. Generally, we can say that the pH of the water samples collected reflects alkaline nature.

Sodium ion concentration variation alters from 40 to 110 mg/l. Sample from bore well A has shown higher concentration of 110 mg/l, whereas bore well B has shown about 40 mg/l of sodium ion concentration.

It can be observed that fluoride ion concentration variation alters between 0.1 and 0.2 mg/l. Sample from bore wells C and E has shown higher concentration of 0.2 mg/l, whereas the water samples from other bore wells have shown small variation.

Generally, by observing the overall variation in concentration of various parameters analysed on water samples collected from bore wells, it can be stated here that the water samples collected from bore wells A and E have shown increased concentration of almost all the parameters analysed, the reason may be that bore wells A and E are located very close to the industrial waste dump site at a distance of about 100–250 m from the dump site.

5.1. Risk assessment of site

Based on the field visits, physical observation of the waste type and quality, with experience, the sites were graded as severe (S), moderate (M) and less effective (L) with respect to the possible impact on man and environment. The grading of sites is totally a rough estimation of the impact but not a detailed estimate of the impact.

5.2. Discussion

The water analysis results have revealed that the ground water around the dump site area is contaminated. But the levels of contamination seem to be relatively low. This could be due to the following reasons:

- Since the water sampling was conducted during the dry season when the level of ground water table was low, fewer amounts of contaminants might have reached the ground water.
- The reported lower concentration of various parameters may also be inferred with the type and structure of the soil strata existing below the ground level.

After the analysis of the water samples from the different bore wells, it was observed from the results obtained that there is a definite need for treatment of extracted ground water from the bore wells in the study zone. Water needs to be treated before supplying the same for consumption. The water seems to be rich in metallic constituents and hence it is not recommended for domestic usage. The water after primary treatment can definitely be used for industrial purpose and for other non-domestic purpose.

The industrial waste needs to be segregated from domestic waste and transported to the common treatment and disposal facility (TSDF) site for storage. Actions have to be taken to stop illegal dumping of municipal and industrial waste at all dump sites. There is a strong need for development of the waste treatment and disposal facility for all cities. Surface or ground water contamination can be reduced by providing bunds, using sheet pile wall and slurry trench cut off walls around the site as the case demands.

Advantages of conducting waste dump site remediation activities are listed as follows:

- Remediation activities of the sites improve the land value, living standard of people and greatly reduce health and epidemic risks associated with illegal dumping of waste.
- Improved health condition will result in improved social status, thereby improving human resource.
- The site remediation reduces the health risk associated with rag pickers and such groups of people.
- Remediation activity of the site will greatly improve the surrounding water, soil, air quality and improves the aesthetics of the locality.
- Monitoring water samples around the site will give a clear picture of the nature and extent of contamination.

6. Conclusions

The following observations and conclusions were made from the present study. The study revealed presence of more than 60 open dump sites present in and around the city of Bangalore. There are more than 35 sites possessing a mixture of domestic and industrial waste. The disposed waste consists of industrial hazardous waste and household hazardous waste along with domestic waste. Some of the sites were found to be very environmentally sensitive and will have an impact on man and environment.

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