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An Overview of Karachi Solid Waste Disposal Sites and Environs

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Impact assessment is a powerful tool that has been remarkably successful in allowing the consideration of social, economic and environmental effects. The development in Pakistan is supported with the growth of the gross domestic product, the steady increase of the population and the change of lifestyle; resulting waste amounts have also increased considerably. Karachi is the largest metropolitan city of Pakistan with 10% of total population of country and generating more than 10,000 ton/ day solid waste. The main purpose of this study to assess the environmental impact of landfill sites activities in the study area. The impact of the solid waste activities in the area was consider on the area's geomorphology, geology, air and water quality, biological resources and socio-cultural environment is considered. Potential impacts identified through review of literature, professional judgment, SWM process understanding and field observations at different landfill sites. Sampling was carried out of air, soil and groundwater samples and analysis them physical and chemical parameters. The finding of soil analyses reveals that soil is sandy with

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brown to yellowish brown color. pH range from 7.25 to 8.08, sulphates concentration is high. CO_2 and CO level in air is higher according to national environmental quality standards. Analysis of groundwater samples showed that groundwater from most of the sites was within acceptable range. The major environmental impacts are land uptake, quality of resources, disturbance of small mammals and wild life.

Keywords: Solid waste; impact assessment; Karachi; landfill site; NEQS.

1. INTRODUCTION

The solid waste management is a big challenge of any urban city of the World [1,2]. Solid waste is directly related to urbanization, living standards and consumption pattern, it is by-product of human activities [3]. According to the definition Solid waste as non solid material that has no value to the person who is generating it [4]. Municipal Solid Waste is residential and commercial wastes produced in municipal or notified areas, including treated bio-medical wastes but excluding industrial hazardous wastes [5].

The volume of waste generated in any given society is directly related to population growth, urbanization, industrialization, economic activities and household consumption levels [6,7,8]. The modes of disposal of these wastes depend on the cultural practices of the people who live within the society. Due to the environmental as well as public health reasons collection, processing, transport and disposal of solid waste are very important [9,10,11]. The amount of solid waste within the living environment exerts negative effects on public health. With respect to health, indiscriminate dumping of waste increases the risk of transmission of wide range of communicable diseases. Different strategies have been proposed for reducing, reusing, recycling, recovering energy and disposing of solid waste [12,13] but these strategies are controversial according to the environmental impacts [14,15,16,17,18]. Solid waste management is a worldwide phenomenon [19]. It is a great challenge for the human beings of all over the world. Impact assessment is a preventive and protection tool for environment which makes it possible to comply with environmental policies, and even incorporates early such policies into the development and decision making processes. The aim of this study to evaluate the landfills related activities and operations against Pakistan Environmental Protection Agency standards and against international environmental guidelines

2. STUDY AREA

Karachi is the biggest city of the Republic of Pakistan which locates in the northwest of the Indus River Delta and at the south of Arabian Sea with population more than nineteen million [20], this accounts around 10% of total population in Pakistan and growing with twice of national growth rate [21]. Half of the population is migrated from rural and upper areas. Increase in population therefore leads to problems urban poverty, housing and transportation, destitute people or informal squatters, waste generation, water and sanitation, and other problems related to urban infrastructure and congestion of city. The study area is Karachi city consisting 18 towns with 10 landfill sites (Table 1).

The city of Karachi is also facing the poor municipal solid waste management system. Waste management is an important issue for mega cities to use urban waste in the most resource recovery and energy-efficient manner considering that landfill is not a sustainable option for waste management in general [1]. Solid waste is important income source of many poor families, it is sold and bought just like other material. For the reduction of poverty, integrated approaches for waste management can be used [22]. City generates more than 10,000 tons per day municipal solid waste, from which 60% is dumped at the landfill sites and the remaining 40% remains on the streets, which is not properly collected [23]. The existing solid waste collection and transportation management system in Karachi is not perfect. There is a lack of long term plans, as a result in a number of disjointed, ad-hoc and often counterproductive plan, policies and administrative frameworks. The municipal infrastructure construction has been lagged behind by the economic development, which become the bottle-neck to the hinder the faster and better development of the municipal economy. Waste collection, disposal and transport as well as street sweepings responsibility lie with the municipal authorities [24,25].

2.1 Statutory Requirement and Standards in Pakistan

The Pak EPA (Pakistan environmental protection agency) was established under section 5 of the EPA. The power to make rules is held by the government e.g. the Hazardous Substances Rules 2003, the Hospital Waste Management Rules 2005, the National Environmental Quality Standards rules. The National Environmental Quality Standards (NEQS) were recognized in 1993 and have since been revised. Similarly EPA started work on drafting environmental guidelines since in 1996. The enactment of Pakistan Environmental Protection Act, 1997 conferred to more broad-based environmental governance and enforced power on the Environmental Protection Agencies within the overall framework of sustainable development. The Pakistan Environmental Protection Act 1997 is a pioneer legislative instrument considered purposely for the protection of the environment.

The most important document for environmental issues in the country is National Conservation Strategy (NCS), which was approved by the federal cabinet in March 1992. The NCS identified 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural environment. It includes biodiversity conservation, pollution prevention and abatement, the restoration of rangelands, and the preservation of cultural heritage. The Pakistan Environmental Protection Act, 1997 is the fundamental legislative instrument empowering the government to frame regulations for the protection of the environment.

2.1.1 National laws and regulation

The first specific governmental commitment to environmental improvement and to deal with the matter of waste in Pakistan is "Pakistan Environmental Protection Act, 1983". As federal legislation, the ordinance established the Pakistan Environmental Protection Council (PEPC), headed by the president of Pakistan, as the supreme environmental policy making body in the country and the Pakistan Environmental Protection Agency (Pak EPA) at the federal level and the environmental protection agencies at provincial level in four provinces of the country to administer and implement the provisions of the ordinance. The Pakistan Environmental Protection Agency (the body mainly responsible for enforcing the Pakistan Environmental Protection Act) has issued national environmental quality standards. In 1997 the improved ordinance was enacted, after the approval from the Parliament as the Pakistan Environmental Protection Act (PEPA).

2.1.2 International treaties

Perhaps our most urgent task today is to persuade nations of the need to return to multilateralism, after a decade and half of a standstill or even deterioration in global cooperation the time has come for higher expectations, for common goals pursued together, for an increased political will to address our common future [26]. Pakistan is a signatory to various international conventions and treaties on environmental conservation and protection of wild life. The country is obliged to adhere to the commitment specified in these conventions and treaties (Table 2).

3. SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

3.1 Demographic

Karachi comprises the world second most populated city. The city credits its growth to the

Table 1. Locations of landfill sites

No	Name of sites	Coordinates	No	Name of sites	Coordinates
1	Jam Chakro	N = 25 01. 675 E = 67 01. 61	6	Lines Area	N = 24 51. 903 E = 67 02. 292
2	Gond Pas	N = 25 00. 634 E = 66 55. 263	7	Orangi	N = 24 56. 210 E = 67 00. 379
3	Dhabeji	N = 24 48. 804 E = 67 30. 567	8	Meva Shah	N = 24 53. 332 E = 67 00. 338
4	Mehmoodabad	N = 24 50. 906 E = 67 04. 212	9	Korangi Graveyard	N = 24 51. 527 E = 67 11. 206
5	Safari Park	N = 24 55. 241 E = 67 06. 391	10	Bilalabad	N = 24 57. 041 E = 67 02. 195

Table 2. Multilateral environmental agreements (MEAS)

MEA	Purpose	Date adopted	Entry into force	% of nations are party to MEA
Ramsar convention	To conserve and promote the wise use of wetland	1971	1975	70
World heritage convention	To establish an effective system of identification, protection and preservation of the cultural and heritage.	1972	1975	91
CITES	To ensure that international trade in wild plants and animal species does not threaten, protect endangered species, conserving habitat.	1973	1975	84
CMS	To protect wild animal species that migrate across or outside national boundaries	1979	1983	44
UNCLOS convention	To establish comprehensive legal order to promote peaceful use of the oceans and seas.	1982	1994	74
Vienna convention	To control the stratospheric ozone depletion	1985	1988	96
Montreal protocol	To reduce and eliminate emission of ozone depleting substances	1987	1989	95
Basal convention	Management of hazardous waste management	1989	1992	82
UNFCCC	To stabilize greenhouse gas concentration in the atmosphere	1992	1994	97
CBD	To conserve biological diversity and promote diversity	1992	1993	97
UNCCD	To combat desertification	1994	1996	97
Kyoto protocol	For climate change by reducing green house gases	1997	2005	57
Aarhus convention	To guarantee the right of access to information public participation in decision making	1998	2001	13

mixed population of economic and political migrants from different national, provincial, linguistic and religious origins largely come to settle here permanently. The solid waste dump sites are mainly based at lower and middle class localities of Karachi. Fig. 1 shows the population distribution within one kilometer radius of the study sites. There are two sites in densely populated areas i.e. Mehmoodabad and Lines Area. The livelihoods of the people in the study area mainly depend on labor, jobs and small business. Majority of the people belong to lower-middle class (Fig. 2).

3.2 Education

The education facilities in Karachi at present are over and above the national standards of educational level. Educational facilities are available in 90% of areas covered due to commercialization of education and active role of private sector. Private organization, NGOs, autonomous bodies have all taken part in providing educational facilities. 60% of schools in the study areas are run by private system. Literacy rate and percentage of school going children were reported different at different areas (Table 3).

3.3 Health

There is lack of adequate health facilities in the area. The numbers of government health facilities are very low as less than 20% area has a health facility provided by the government. The people of this area suffer great pollution, sanitation, garbage and unhygienic condition problems. The most common health problems of the study area are respiratory disease (chest infection, cough and cold), waterborne disease (gastro, hepatitis) and infectious disease.

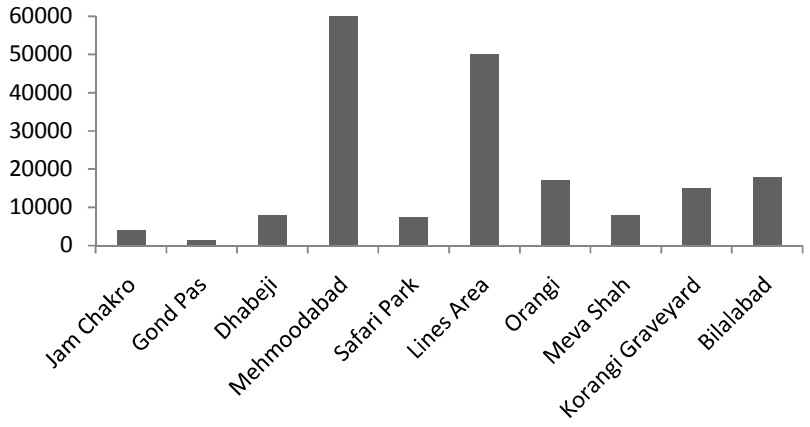

Fig. 1. Population distribution within study area

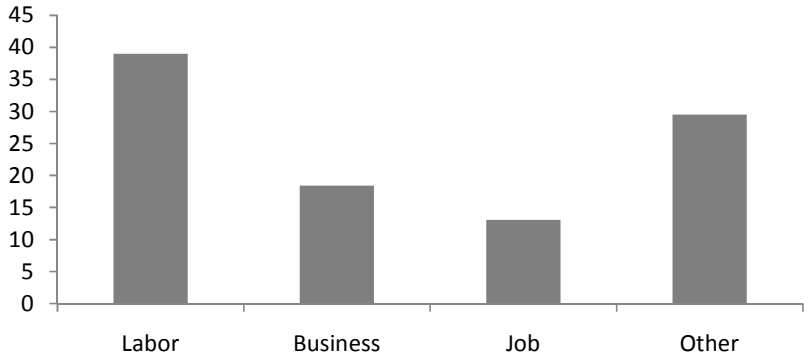

Fig. 2. Livelihood of the people around study area

Table 3. Overall literacy rates in percentage

No	Landfill sites	Percentage (approximately)			
		Literacy rate		School going children	
		Women	Men	Girls	Boys
1	Jam Chakro	0	1	5	15
2	Gond Pas	0	1	0	1
3	Dhabeji	10	20	20	40
4	Mehmoodabad	40	60	60	75
5	Safari Park	20	40	50	60
6	Lines Area	35	60	50	75
7	Orangi	15	40	25	60
8	Meva Shah	20	50	30	60
9	Korangi Graveyard	5	20	10	30
10	Bilalabad	30	60	50	75

4. MATERIALS AND METHODS

Faunal data was collected by different methods at random locations within the study area, variety of techniques were used to establish the presence and distribution of species. To determine the water, soil and air quality samples were collected. For groundwater samples the physical parameters, pH, electric conductivity and total dissolved solids were performed on

unfiltered samples with the help of Sension 156 HACH, USA. For chemical parameters groundwater sample analysis was carried out for chloride, calcium and magnesium by titrimetric methods. Remaining parameters were determined by DR - 2800 UV VIS spectrophotometer of HACH USA. In case of soil tests samples were analyzed according to manual procedure of soil test kit model no. SIW-1 HACH, USA. Procedure for air investigation was followed that was adopted by Ghose [27] in his study to measure the air pollution status. Literature was reviewed for secondary data on weather, soil, water resources, wildlife, vegetation and communities. Information on relevant legislation, regulations, guidelines and standards was reviewed. Some personal interviews conducted with the key stakeholders. In the light of collected information potential environmental issues were identified.

5. RESULTS AND DISCUSSION

5.1 Geology

The geology of the areas is composed of sedimentary formation of marine origin. Lithologically sand, clay, limestones, sandstones and shales are found in the area, having geological age from Recent, Gaj to Nari. Limestones present in the project area are of argillaceous and arenaceous character. Some other limestones are rich in corals. Some sandstones possess cross bedding. Structurally the study area is complex one as anticline or domal structure particularly near Orangi Hills has been eroded because of weathering and erosion of softer material i.e. shale, soft limestone etc. Local faults and unconformities are visible.

5.2 Geomorphology

The geomorphology provides a structure for describing and explaining the pattern and the process described as a result of close association between vegetation types and geomorphology. It is also useful in terms of the changes that are taking place in erosion and deposition over a time. The area is composed of mostly limestone and sandstone formations, that have been uplifted and compressed by Cenozoic collision of the Indian subcontinent with Asia, which has resulted into formation of a plunging anticline or domal structure near Orangi hills near Manghopir, cut by fault.

5.3 Soil

The finding of soil analyses reveal that the texture of the soil ranges from sandy to loamy sands and sandy loams. The colors are brown to yellowish brown. Their pH value ranges from 7.25 to 8.08. Very high conductivity particularly at Gond Pass (sample 1, 2 and 3), Dhabeji (sample 1), Meva Shah (sample 2), Korangi Graveyard (sample 1, 2 and 5) and Mehboodabd (sample 1) suggest that these are saline soils, whereas low conductivity at Jam Chakro(sample 1 and 2), Korangi Graveyard (sample 1), Gond Pass (sample 4), Meva Shah (sample 3), Orangi (sample 1), Dhabeji (sample 2) and Shipowner Collage site suggest these are non-saline soils. Safari Park and Korangi Graveyard (sample 4) are semi-saline soil with medium conductivity. Chemical analyses of soil further reveal that saline soils are particularly rich in sulphates as comparison to nitrates or phosphates. Due to the presence of industrial chemical waste at Gond Pass and Orangi sites the concentration of sulphate is high and phosphate is comparatively low. The Dhabeji site is rocky and soil contains 310 – 2050 mg/l sulphate, 14 – 68 mg/l phosphate and 130 – 150mg/l nitrate. Soil from the Korangi area site showed high concentration of sulphate because of pharmaceutical waste (Fig. 3).

5.4 Air Quality

Air pollution is a significant factor shaping public health. It is a critical problem in Karachi city with possibly serious health impact. Result shows that the concentration of CO_2 and CO in air is higher/ exceeding NEQS levels at most of the sites. The Jam Chakro is highly polluted area with concentration of CO_2 is 372 - 405 ppm and PM10 is 319 - 350 $\mu g/m_3$. In Gond Pass site the smell of organic waste was spread in the area, CO and CO_2 concentration is very high range 2.5 – 7.8 and 386 – 430 ppm respectively. Dhabbeji site is fresh but at the short distance various industries have been established that can pollute air and high concentration of CO_2 350 – 360 ppm. Concentration of CO, CO_2 and PM10 at Korangi site is 1 – 1.6 ppm, 360 – 375 ppm and 240 – 270 $\mu g/m_3$ respectively, higher then NEQS level. Safari park and Shipowner collage sites are unpolluted and concentrations are within NEQS level. In Mehmoodabd site the concentration of CO_2 in air is higher range 350 – 352 ppm. The reason of higher concentration is because of asphalt plant and auto exhaust. The

concentrations of other factors in most of the sites are below the detection limits (Table 4).

5.5 Water Quality

Freshwater resources can be contaminated by leachate from landfill sites. Leachate may cause water pollution if not properly managed. Surface water from a landfill site can cause unacceptable sediments loads in receiving water, while uncontrolled surface water runoff can lead to excessive generation of leachate. The water quality in the study area suggests that the surface water at Jam Chakro Landfill site is acceptable quality for drinking and agriculture purposes. The samples were obtained from Hub Canal which is flowing in the area. There is no sign of leachete effect on it because canal has been completely lined to save it from infiltration into adjoining land. Surface water at another landfill Gond Pass site when chemically and biologically tested, found not fit for drinking or agriculture purpose. Looking to its quite high values of TDS 3672 mg/l, Cl 1496 mg/l and particularly SO_4 at 720 mg/l, there is possibility that water might be gradually effected by leachete. Surface water at Dhabeji site could not be found, however quality of groundwater found satisfactory. Since this landfill site is newly proposed and to be developed in stages therefore currently there is no garbage which is being dumped consequently effect of leachete could not be measured. TDS limits between 842 mg/l to 1842 mg/l and biologically also within limit. Groundwater quality from Meva Shah was found highly contaminated chemically as well as biologically. Groundwater at Lines Area is fit chemically and biologically. Groundwater of Korangi site is chemically marginal, however biologically not fit for drinking. TDS is 1029 mg/l with Cl and SO_4 within WHO limits while total coliform are higher. Orangi and Mehmoodabad sites no groundwater (well or tube well) is available, however surface water found from a small depression is chemically within WHO prescribed limits (Table. 5).

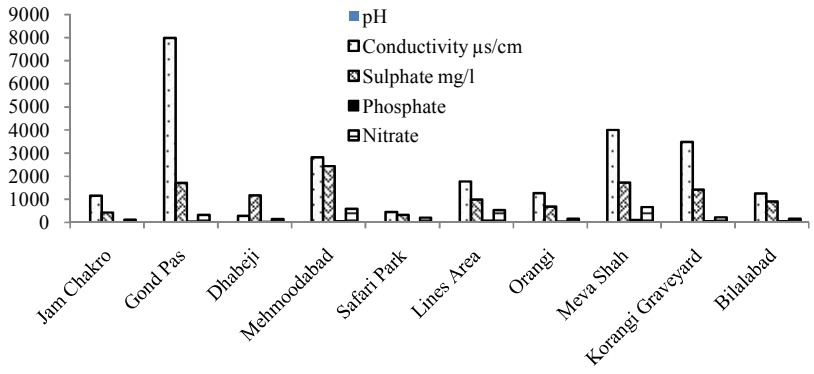

Fig. 3. Showing the analysis result of soil

Table 4. Air quality in the study area

No	Landfill sites	CO		CO_2		NO_2		SO_2		Ozone		PM10	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	Jam Chakro	2	6.2	372	405	BDL	BDL	BDL	BDL	BDL	BDL	319	350
2	Gond Pas	2.5	7.8	386	430	BDL	BDL	BDL	BDL	BDL	BDL	309	329
3	Dhabeji	BDL	BDL	350	360	BDL	BDL	BDL	BDL	BDL	BDL	86	173
4	Mehmoodabad	BDL	BDL	350	352	BDL	BDL	BDL	BDL	BDL	BDL	80	86
5	Safari Park	BDL	BDL	350	355	BDL	BDL	BDL	BDL	BDL	BDL	135	140
6	Lines Area	1	1.2	360	355	BDL	BDL	BDL	BDL	BDL	BDL	165	135
7	Orangi	1	1.6	355	370	BDL	BDL	BDL	BDL	BDL	BDL	164	170
8	Meva Shah	2.1	6.2	370	400	BDL	BDL	BDL	BDL	BDL	BDL	290	340
9	Korangi Graveyard	1	1.6	360	375	BDL	BDL	BDL	BDL	BDL	BDL	340	370
10	Bilalabad	2	3.4	350	365	BDL	BDL	BDL	BDL	BDL	BDL	250	340

Table 5. Water quality of samples collected in the study area

Location		Depth	TDS	pH	HCO_3	Cl	SO_4	Ca	Mg	K	Na	E.C
N	E	(m)						mg/l				µs/cm
24 51.527	67 11.206	12	1092	7.1	299	289	135	46	6	12	302	1330
24 51.580	67 10.885	15	1232	7.5	311	232.8	280	50	7.2	20	328.4	1655
24 51.903	67 02.292	2.4	568	6.8	162	107.9	105	42	6	8.5	131.2	938
24 51.903	67 02.303	3.6	912	7.2	199	244.2	150	46	6	8.9	254	1825
25 01.004	66 53.353	12	3672	7.6	124	1497	720	280	24	48	968.6	6430
24 53.071	67 00 48.5	22.7	5764	7.2	274	2102	1360	280	30	54	1661	10530
24 56.210	67 00.397	1.2	452	7.2	62.2	113.6	118	30	2.4	8.1	112.8	782

6. CONCLUSION

The climate of Karachi can be characterized by humid and moderate to hot condition. The mean minimum and maximum temperatures vary from 0ºC – 47ºC, high temperature are experienced in summer. Mean annual rainfall at Karachi is 203 mm. Most of the sites have poor air quality due to improper landfill operation and dumping. The air quality especially at Jam Chakroo and Gond Pass sites is highly polluted, CO_2, CO and PM concentration is higher than NEQS. Dust and gas emission can give rise to nuisance and health problems. The Ph of groundwater samples is slightly alkaline and more than 70% samples have higher TDS and conductivity which showed the leachete effect. Most of the area is covered with subtropical scrub vegetation like *Accacia senegal*, *Accacia nilotica*, *Prosopis cineraria*, *Prospis juliflora* are naturalized, Zizyphus moniciatinen, *Tamarix dioca*, Salvadora and some species of zerophytic grasses are found. Many wildlife species and bird species are present. Many reptile species like snake and lizards are found due to humidity and normal temperature. The livelihood of the people in study areas mainly depends on garbage collection and labor work. Different communities have settled in areas for purpose of garbage collection and selling. There is lack of adequate health facilities in the areas. The people of these areas suffer great pollution, sanitation, garbage and unhygienic condition problems. The biodiversity of the area and its surrounding consist of 154 species, 34 mammals, 154 birds, and 20 reptiles. The communities present are poor and vulnerable with low human development indicators.

6.1 Final Comments

The potential impact of landfill sites in most of the areas is significant and overall the following improvements are needed

- Improvement in health conditions of the city resident as in the existing conditions many diseases outbreak due to waste mishandling.
- Need to improve waste transported in proper vehicles avoiding the dropping of waste on streets while transportation.
- Significant reduction of land/ groundwater contamination is needed
- Significant reduction in air pollution as the open burning of waste is currently done at landfill sites and even along roads
- Significant improvement in the health conditions of workers of dumping sites.
- Clean city will give a better aesthetic value

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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