Research Journal of Applied Sciences, Engineering and Technology 7(8): 1551-1560, 2014
DOI:10.19026/rjaset.7.431
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: May 10, 2013 Accepted: June 06, 2013 Published: February 27, 2014

Research Article

Municipal Solid Waste and its Relation with Groundwater Contamination in Lahore, Pakistan

Akhtar Malik Muhammad and Tang Zhonghua
School of Environmental Studies, China University of Geosciences, Wuhan 388 Lumo Lu, Wuhan 430074, Hubei Province, P.R. China

Abstract: Solid waste dumping sites always pose serious environmental problems on air, soil, surface water and groundwater. Landfill leachate contains thousands of complex components and become part of groundwater after infiltration. Vicinity communities are comparatively more affected through hazard activities. Generally, it is regarded as global issue but problems are more sever in developing countries due to mismanagement and lack of related facilities. The present study investigated the landfills effects on groundwater system in Lahore city, Pakistan. Sixteen points were selected for groundwater sampling in the study area during 2010 and were analyzed for selected twelve parameters. Samples were collected to and far from three dumping sites and found in mostly samples contains high pollutants concentration than Pakistan Standards and Quality Control Authority (PSQCA, 2004) and arsenic concentration over World Health Organization (WHO) drinking water criteria. Dumping sites impacts are in result of changing groundwater chemistry, waterborne diseases and other environmental issues. Numerous studies have been conducted but still a comprehensive research needs with boarder aspects to preserve and protect groundwater resources.

Keywords: Groundwater, Lahore, landfill, leachate, pollution, solid waste

INTRODUCTION

Water is important as many aspects for human survival and other living organism. Fresh water is essential for their healthy growth; otherwise contaminated water will be source of various health issues (Kendall, 1992). Worldwide water resources are under stress, however in Asia situation is much complicated. Due to high population growth, urbanization, agricultural practices (excessive use of fertilizers, pesticides and other chemicals), industrialization, poor sanitation services, unplanned solid waste management and improper water consumption practices has affected both water resources quality and quantity (Haydar, 2012).

Big cities are facing almost similar issues globally like in Pakistan; the population of Lahore city is rapidly increasing due to migration from rural areas to enjoy modern social facilities. Urbanization exerts more stress on limited natural resources of a region, social and physical infrastructure, which leads towards various social, economic and environmental challenges (Energy Sector Management Assistance Program (ESMAP), 2010)

Solid waste management is becoming a challenge over the time, especially in high populated cities. Therefore, landfills and open-dumping sites are regarded cheapest and easiest way to manage solid waste in different parts of the world (Longe and Balogon, 2010; Jhamnani and Singh, 2009). Disposal of solid waste and sewage, urban runoff, agricultural activities and polluted surface water are major contributors to deteriorate urban groundwater resources (Jain *et al*., 1995). Surely, landfill sites generally seem as rescue for urban areas to handle garbage issues but groundwater has major threat from these sites due to unplanned activities (Longe and Balogon, 2010; USEPA, 1993). Many studies have been conducted in various parts of the world to assess groundwater quality and landfill impacts with applying different methodologies and approaches to investigate ground water contamination, bacterial presence and high concentration of toxic heavy metals etc., (Mor *et al*., 2006). Many researchers (Akinbile and Yusoff, 2011; Longe and Balogon, 2010; Vasanthi *et al*., 2008; Abu-Rukah and Al-Kofahi, 2001) have been examined municipal landfills possible impacts on groundwater resources by using microbiological examination and physicochemical analysis of landfill leachate and ground water. They explored that landfill sites are major threats for the groundwater, local environment and communities as well.

Corresponding Author: Tang, Zhonghua, School of Environmental Studies, China University of Geosciences, Wuhan 388 Lumo Lu, Wuhan 430074, Hubei Province, P.R. China, Tel./Fax: 0086-13627279749/027-87436235

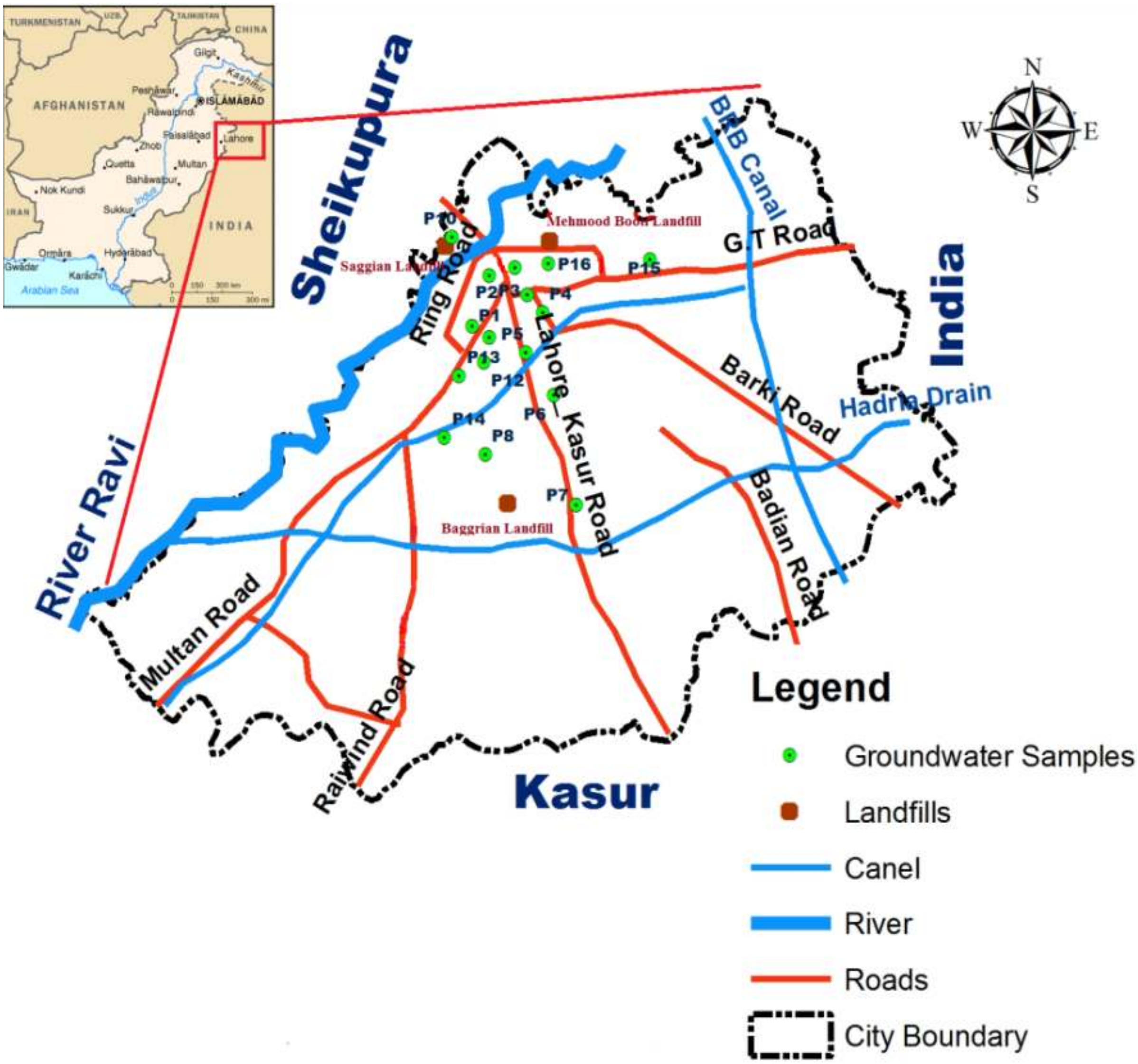

Fig. 1: Locations of landfill sites and water sampling around Lahore city

Currently, Pakistan is facing health and environmental problems due to improper solid waste management in different parts of country especially major cities. Less than half generated solid is collected due to inadequately disposed off at dumpsites, along roadsides or incinerated without considering air and water pollution at Lahore city (Energy Sector Management Assistance Program (ESMAP), 2010). In Punjab Province groundwater is being use for water supply, agriculture and other sectors, therefore it is major source of water. However above mention reasons are main cause to degrade groundwater quality. With reference to Lahore city, groundwater and surface water is suspected to be contaminated due to the unplanned landfill sites (Haydar, 2012). Particularly in Lahore, the groundwater is suspected of being polluted (Karim, 2010) due to untreated waste water and three dumping sites (the Mehmood Booti, Saggian and Baggrian landfills) located in various parts of the city. These dumping sites are unplanned and have no proper and effective system to collect leachate. So it is suspected that leachate goes down through the soil and is mixed with groundwater because there is no proper mechanism to collect leachate and protect aquifer. This study evaluates water supply and quality issues of water supplied in Lahore city with reference to its groundwater quality. Mehmood Booti Landfill is the oldest municipal disposal site of Lahore and though officially named as landfill but still it is non-engineered landfill where open dumping is carried out (Haydar, 2012).

In the present study an attempt is made to assess the ground water quality and its possible relation landfill sites impacts on groundwater pollution to the

Lahore city. It can estimate that with continuity of present environmental hazards practice will make natural resource unfit for human use.

Aims and objectives: The objectives of this study are:

- To understand the physical and chemical solid waste composition and landfill sites condition
- To expose the impacts of open dumping sites on ground water under lying Lahore aquifer
- To investigate current groundwater quality and possible contamination relation with landfill activities

Study area: Lahore, the second largest city of Pakistan and capital of Punjab province, has an approximated population of 10 million (Ahmad *et al*., 2012). The Lahore area is located between 31°-15′ and 31°- 42′ north latitude, 74°- 01′ and 74°-39′ east latitude with altitude ranging between 208 to 213 m ASL and situated on the vast alluvial plain on bank of Ravi River. Lahore district is bordered on the north and west by the district of Sheikhupura, with the east side by the country of India (international border) and on the south by Kasur district (Fig. 1). The estimated population of the city is over 9,226,092 persons with annual 3.5% average growth rate (Lahore CDG, 2011).

The region is characterized extreme weather variations in rainfall and temperature. Mean annual temperature is estimated approximately 24 ranging from 46°C in June to 2°C in January, while about 575mm average annual rainfall vary from 300 to 1200 mm. June to September are regarded as most rainy months with 75% of the total year and contributes over 40mm to groundwater recharge in a year. Where the total evapotranspiration rate is 1750 mm/annum, while can exceed rainfall and making irrigation process for agriculture essential addition rainfall (NESPAK, 1993: (Dogar, 2008). Relative humidity potential is showed big difference in winter (higher at day time) and summer.

There are three active dumping sites present in study area but they are unplanned and non-stationary. River Ravi the major recharge source is receiving untreated industrial, municipal and agriculture waste water. WASA is major authority to maintain and manage water supply and sanitation system in Lahore city.

SOLID WASTE GENERATION AND PROCESSING

The complex nature of different waste materials (municipal, commercial, industrial, agriculture and hospital waste) makes it challenging to prevent natural resources such as groundwater from hazard effects of generated toxic leachate which is extremely risky for general public. However, the level of threat depends on three major factors; leachate composition, quantity of leachate and distance from pumping well (Słomczyńska and Słomczyński, 2004).

The dumping sites around Lahore city are old, unplanned, unsafe and traditional. The city is experiencing urban sprawl and rapid industrialization, which is a leading contributor to the generation of a huge amount of solid waste. About 5,700 tons of solid waste is generated daily in Lahore city from different sources that contains a high percentage of organic waste (up to 67%) and this volume is equivalent to a generation rate of 0.84 kg/capita per day, which is lower than world's average of 1.2 kg/capita per day (Batool and Chuadhry, 2009). At least three-quarters of the total waste generated (3800 tons/day) in Lahore is dumped at these sites without proper treatment. Figure 1 shows the locations of three landfill sites, e.g., Mehmood Booti, Saggian and Baggarian.

The Mahmood Booti Landfill is located north of Bund Road, about 5 km away from River Ravi. It is the second major landfill site which contains Lahore Compost Plant on 15 ha (Lahore, 2008; Hayder *et al*., 2012) and solid waste from the Shalimar Town, Aziz Bhatti Town, Data Town and a part of Gulberg Town area is being dump. The site has been receiving solid waste since 1995 and it covers an area approximately 630 kanals. There is almost 1200 to 1500 tons of solid waste being dump per day, which is nearly 30 to 40% of total collected daily solid waste from Lahore (Butt and Ghaffar, 2012). Presently, the Mahmood Booti landfill site has been managed by the City District Government Lahore (CDGL), so the site is recently owned by the solid waste management department. A computerized weigh bridge has been installed at the site to keep a record of daily waste.

The Saggian landfill site is located along the Ravi River and continually pollutes the soil, groundwater and river water. Saggian Landfill site is also popular dumping site situated along the road running from main Bund Road to Saggian Bridge on bank of River Ravi. This is very hazardous from environmental point of view. This is the largest dumping site in the city with an area of 81 ha. More than 1800 to 2200 tons of waste brought to the site every day, primarily from the towns of Ravi, Samanabad, Data GunjBux and Gulberg.

The third site is the Baggrian landfill located in Nishtar. It is a small site of only 5 acres within a 30 m depression. Approximately 300-350 tons of waste is dumped daily from the towns of Gulberg, Allama Iqbal and Nister.

These three sites are totally unorganised and do not have mechanism to collect complex leachate and toxic gases produce due to continues chemical process. Solid waste at the sites do not properly covered clay layer to provide protection from rain penetration. These sites are considered hazard for environmental point of view and especially groundwater deterioration. The major demerit of open dump is that soil, river water and groundwater is being contaminated.

Solid waste composition and leachate chemical analysis: It is general concept that unplanned and poorly built landfills are directly and/or indirectly threat for human health by deteriorate to soil and groundwater (Misra and Pandey, 2005).

Groundwater chemistry changes with infiltrating of complex leachate. So, an effective solid waste management strategy is needed to preserve natural resources and protect the regional environment (Sandulescu, 2004). Unfortunately, Municipal Solid Waste (MSW) is highly neglected and poorly managed in all low and most developing countries (Murtaza and Rahman, 2000) like Pakistan. We know that this poor management of waste streams is causing adverse environmental impacts and health hazards. Therefore, appropriate waste management strategies can substantially reduce the burden placed on the environment and to reduce resources depletion (Woodard *et al*., 2004).

The uncontrolled release of domestic, agriculture and industrial effluents in natural water resources are major culprits in the pollution problem in urban areas of Pakistan. All these pollution contributors have their own specific effects e.g., domestic sewage contains high levels of bacterial pathogens and organic material; industrial discharges are rich of toxic metals, organic loads, acids and other less toxic substances; and run-off from agricultural lands contains pesticides and fertilizers. Solid waste disposal in Lahore city is not very well planned and stagnant water bodies are present in low lying areas which is a source of pollution for surface and subsoil water (Karim, 2010). Typically, solid waste from Lahore city contains vegetable and fruit residues, leaves, grass, straw, paper and plastic (Fig. 2).

MSW has become more severe over the last few years due to increased amounts of waste generation. There are no nationally or internationally accepted concentration limits for metallic elements in sewage sludge and MSW. Heavy metals in the MSW, sewage sludge and groundwater are present.

Lahore city are of significant concern because of their environmental impact as toxic metals after accumulation in soils.

Another serious issue is the non-existence of a separate waste disposal site for waste that comes from industrial estates, hospitals or other hazardous sources. Such type of waste materials pose much more severe health risks to workers and the general public. Moreover, solid waste segregation is not well organized because of a shortage of human resources, inadequate tools and equipment, lack of awareness, poor

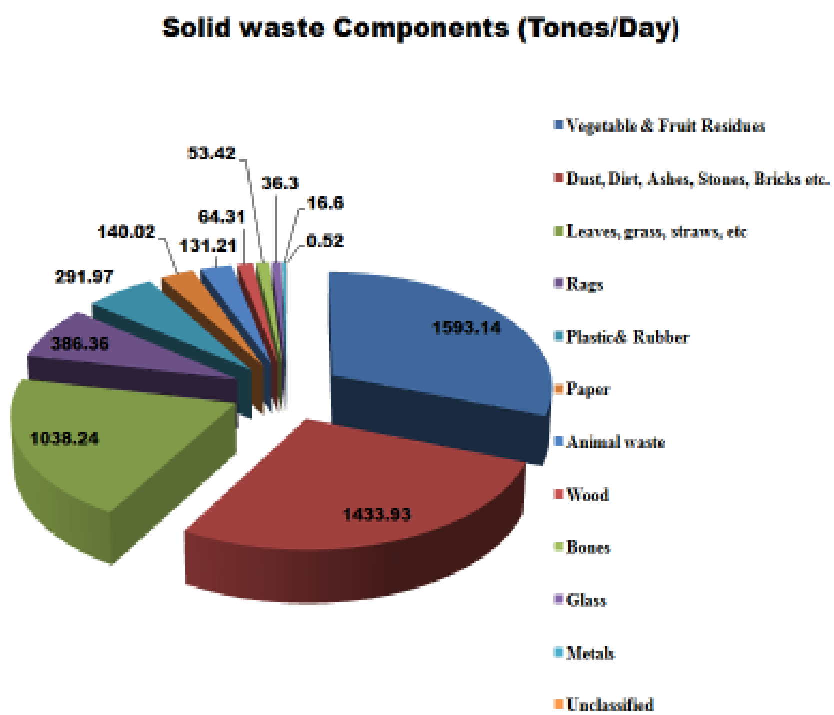

Fig. 2: Composition of typical dumping material at landfills in Lahore city (based on Haydar *et al*., 2012 and LWMC department)

Table 1: Typical analysis of leachate from landfills located in Lahore city

Parameter	Saggian landfill site	Mehmood booti site
pH	6.80	6
COD (mg/L)	2563	18,000
BOD (mg/L)	442	10,000
Grease and oil (mg/L)	0.50	0.9000
Phenol (mg/L)	0.04	0.0600
Surfactant (mg/L)	1.58	1.3000
TDS (mg/L)	3717	3500.0
TSS (mg/L)	161.70	500.0
Conductivity	5829	7154.0
Pb (mg/L)	0.60	
Cu (mg/L)	2.70	
As (mg/L)	0.20	
Fe (mg/L)	9.80	60
Sulfate (mg/L)		300
Total nitrogen (mg/L)		400
Chlorides (mg/L)		500
Total phosphorous (mg/L)		30
	Younas *et al.* (1999)	Tchobangoglous (1993)

infrastructure, poor town planning, inappropriate placement of containers and shortage of educated and skilled professionals. These all are factors which are responsible for poor management. 'The Hospital Management Rules' were introduced in 2005 stating yellow-bagged waste shall be disposed of after burning by burial in a landfill or through any other method approved by the Federal or Provincial agencies concerned.

The present practice of solid waste disposal in Lahore is not properly organized and planned. This poor standard and practice of handling and disposing of untreated polluted industrial and municipal waste is creating multiple environmental problems and challenges in Lahore. The Ravi River plays an important role in recharging the aquifer serving groundwater supplies in Lahore city and the surrounding districts. It is now well documented that the river water has a high level of faecal contamination (Manan, 2008) and poor microbiological quality. In a similar manner, organic and inorganic pollutants are getting into the river water directly or indirectly and then to aquifers. The severity of this problem can be judged from the fact that more than 1,000 industrial units and municipalities are directly discharging more than 5,500 cusecs of untreated toxic effluent into the drains, rivers and natural water channels in the Punjab province. The level of pollution varies from district to district and the Lahore district is the most polluted one. The nature of this effluent varies from toxic to hazardous.

Several studies examining leachate samples from landfill sites (Table 1) showed that most of the parameters such as color, conductivity, TSS, TDS, BOD, COD, NH3-N, PO4-P, SO4-2, Cl-1 and Fe were at high levels. The organic load was quite high since the COD concentrations were in the range of 2530-18000 mg/L. In addition, the low BOD/COD ratio (0.172-0.55) confirmed that the majority of this organic matter was not easily biodegradable. A survey conducted by Naeem *et al*. (2007) also indicated higher concentrations of various constituents. The groundwater near the landfill sites was characterized as non-potable and not suitable for drinking or other domestic uses.

METHODOLOGY

In order to study the effects of municipal landfill sites on the ground water quality 16 water sample sites were selected in various locations of the study area to and far from the sites. The details of water sample sites are presented in Table 2 and their locations are shown in Fig. 1. The samples were carried out from the WASA operational pumping wells which are used for community water supply. The depth of the water sample sites varied between 150 to 180 m and their distance from landfills was different. The purpose for this analysis was to evaluate and compare contamination potential of dumping sites located at different distances from water extraction points. Sample analysis and methodology adopted is as below. Sample bottles were sterilized at 150°C. All the apparatus used in this study was washed with chromic acid and washing reagent then dried in an oven. To prepare reagents double distilled water was used. Analytical grade chemicals and reagents were used in this study without further purification. Inorganic chemicals were kept in the oven at the temperature of 120°C to remove moister where it was necessary.

Table 2: Groundwater chemical analysis results of selected parameters

Name	X	Y	p.H.	Tur.	Con.	TDS	T.H.	Ca	Mg	Alk	Cl	HCO_3	Fe	As
P1	31.5520	74.2829	8.0	0.97	324	504.1	128	27.2	14.4	92	11	92	0.02	89
P2	31.5905	74.2990	8.2	1.30	321	502.2	260	18.2	20.2	152	12	152	0.02	70
P3	31.5745	74.3245	7.6	1.51	813	512.1	260	52.8	30.7	140	72	140	0.02	74
P4	31.5619	74.3360	8.0	1.07	551	347.1	142	27.2	17.7	14.4	35	14.4	0.02	96
P5	31.5325	74.3232	8.0	3.89	631	397.5	100	18.4	12.9	140	42	140	0.02	79
P6	31.5016	74.3442	7.5	0.46	1040	655.2	222	34.4	32.6	236	35	236	0.02	97
P7	31.4218	74.3612	7.6	1.13	815	513.4	256	36.8	17.7	252	32	252	0.02	137
P8	31.4583	74.2927	7.8	2.25	688	533.4	216	17.6	17.2	164	17	164	0.02	143
P9	31.5977	74.3117	8.2	1.55	340	214.2	78	17.6	8.1	120	18	120	0.02	10
P10	31.6166	74.2675	7.8	0.97	435	274.0	178	40.8	18.2	122	40	122	0.02	1
P11	31.5434	74.2956	7.8	1.20	953	600.3	254	46.4	31.2	169	77	196	0.02	105
P12	31.5253	74.2918	7.8	3.81	640	403.2	172	29.6	23.5	296	25	296	0.02	104
P13	31.5157	74.2733	7.7	1.29	610	384.3	192	36.8	24.0	152	25	152	0.02	112
P14	31.4704	74.2622	8.0	2.49	973	613.0	176	26.4	26.4	288	45	288	0.02	120
P15	31.6071	74.3942	7.7	2.05	456	587.2	264	31.2	20.6	138	13	138	0.02	94
P16	31.6003	74.4165	7.9	2.21	516	325.0	66	11.2	9.1	144	28	144	0.02	52

Samples of drinking water were collected from selected points of Lahore in 500 and 100 mL capacity glass bottles for chemical and bacteriological analyses. For bacteriological analysis, sampling taps were cleaned with ethyl spirit followed by a flame to avoid contamination from external environment. Tests for pH, Turbidity, Conductivity and TDS were performed within one hour of collection. For the chemical analysis of trace metals 100 mL water from 500 mL glass bottle was transferred to 100 mL flask with stopper and 5 mL of nitric acid was added as preservative. For nitrite test 1 mL of 1% boric acid solution was added as a preservative to 100 mL sample. For other parameter there was no need of any preservative.

After obtained chemical analysis results of water samples, their concentration will be compare to and far locations of landfill sites. Also investigate the pollutants presence, where were identified in previous studies in landfill leachate. This study will provide a chance to understand landfill leachate effects on groundwater system.

RESULTS AND DISCUSSION

Table 2 shows groundwater contamination concentration potential at selected locations and parameters of study area. On the base of chemical analysis results, the pollutants are compared in Fig. 3 as Pakistan Standards and Quality Control Authority (PSQCA) and World Health Organization (WHO) drinking water standards are also presented. Groundwater sample analysis results indicate that water contamination level is high and some treatment to purify water before use is required. The pollutants have changed groundwater chemistry at study area and landfill leachate has a significant contribution to it. Some researchers conducted studies on dumping sites located at Lahore city and got leachate chemical analysis results (Table 1), these results explored that the pollutants concentration was extremely high. It can be estimated with time complicated chemical compound produce due to biological and chemical process at landfill sites. Various chemicals, heavy metals, organic and inorganic materials are dumping in these sites, which can generate more and more complicated chemical compound with time the number and complexity of compounds will increase.

Currently, these pollutants are part of groundwater (Table 2). Landfills are not properly maintained until recently, it is highly expected that pollutants concentration will keep increasing over the time.

The selected parameters concentration values with xy-coordinate location of 16 points are presented in Table 2. Almost, all selected points indicate that pollutants are part of groundwater system; therefore, use of groundwater without treatment is risky for residents. Pollutants potential is higher near the dumping sites as compare to other part of the study area, but one fact we must consider that due to present of cone in groundwater system contaminants have dispersed in whole study area. This is why, the level and concentration of pollutants in other part of study area is also significantly high, it can expect over the time pollutants will be equally distribute in all parts of study area. According to our analysis and understanding the reason behind this is the formation of cone due to water extraction and movement of groundwater due to the cone has transmitted vicinity pollutants towards main business area. Six parameters are presented and compared with the help of graphs and evaluated by applying two drinking water standards WHO and PSQCA.

Arsenic concentration in groundwater is dangerously high only two samples within WHO (0.01 mg/L) standard and three samples fulfill PSQCA (0.05 mg/L) criteria. Arsenic is regard as poison even present in little quantity. Industrial waste, pesticide and fertilizers excessive use are considered its major sources. Hazard wastes are being dump at landfill sites and other open places without considering its environmental impact. Industrial and agricultural solid waste and effluents should be treated before discharge. Arsenic causes respiratory illnesses, lung cancer and cardiopulmonary (Farooqi, 2007)

The TDS concentration indicates various mineral and solid dissolved in groundwater. High values of TDS can change water taste, hardness and corrosive property of the water (Balakrishnan *et al*., 2011; Hari Haran, 2002; Joseph, 2004). The maximum contaminant level for TDS in drinking water is given as 1000 mg/L by WHO and 500 mg/L by PSQCA standard. However, 100% of the water samples were classified as acceptable using WHO standards but only 50% qualified using PSQCA standards. Subba and Sohani reported that high TDS concentrations are due to the presence of bicarbonates, carbonates, sulphates, chlorides and calcium, which may originate from natural sources, sewage, urban runoff and industrial wastewater (Sohani *et al*., 2001; Subba, 1998).

Calcium and magnesium are generally responsible for hardness in water. In cultivated areas where lime and fertilizers are used, excessive hardness may also be due to other chemicals such as nitrates (The British Columbia, 2007). All of the analyzed samples from Lahore had TH within the prescribed limits of WHO, but 5 have concentration exceeding PSQCA standards (Table 2). Hard water can form scum and curd on boiling, can cause boiled, vegetables to become hard, can cause discoloration of fabrics and can lead to medical problems such as diarrhea, excessive gas, kidney stones and heart problems (Smith and Crombir, 1987; WHO, 2004).

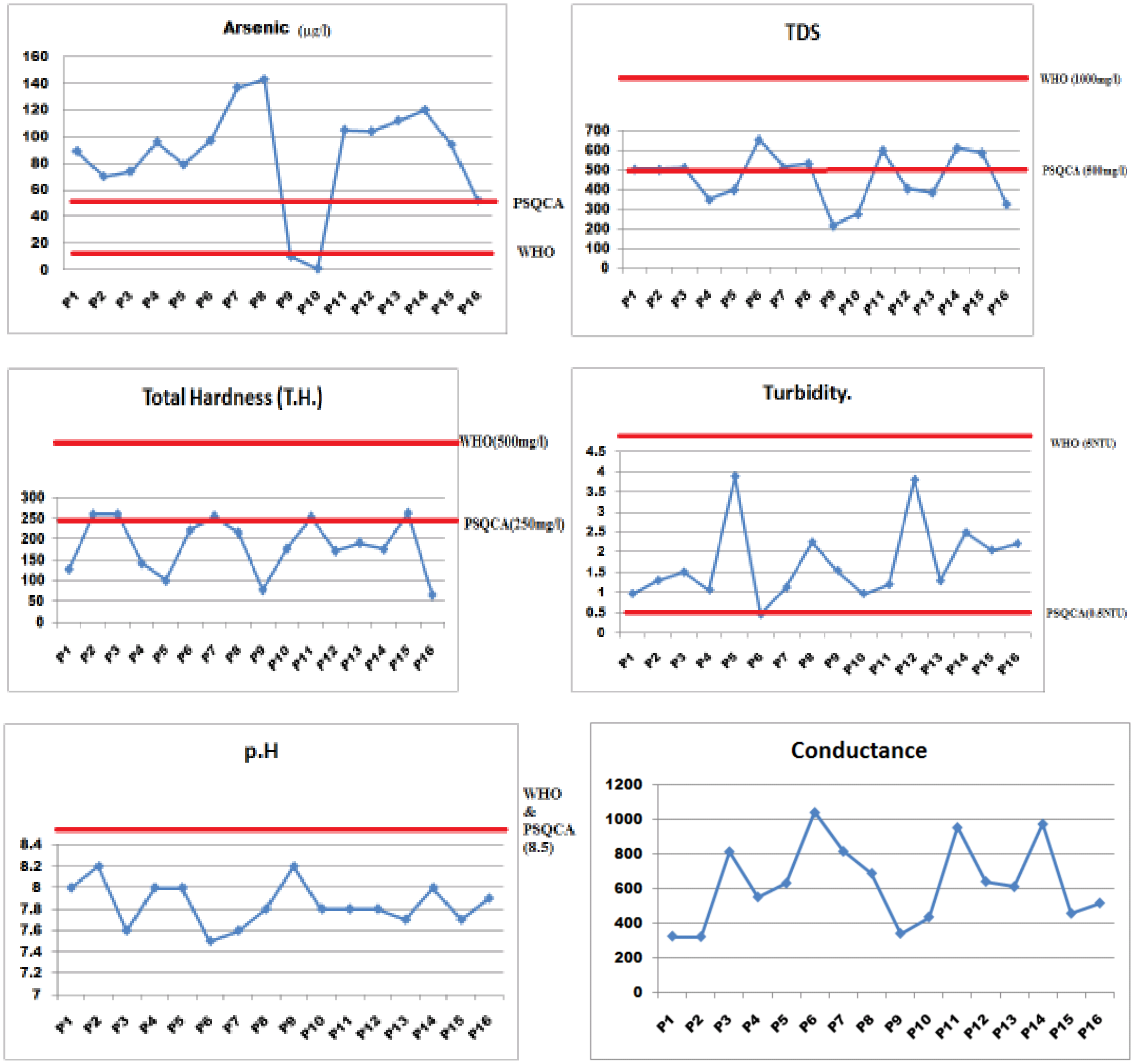

Fig. 3: Six parameters (arsenic, TDS, T.H, turbidity, pH and conductance) are compared, also WHO and PSQCA standards are presented to identify contamination potential

pH is one of the most commonly analyzed parameters in soil and water testing. It represents the acidic or alkaline potential of a solution and is measured on a scale of 1-14. A pH of 7 represents a neutral solution; less than 7 is acidic and greater than 7 is basic. The most acidic solution has a pH of 1, whereas the most basic has a value of 14. Both WHO and PSQCA recommend that pH levels for drinking water be in the range of 6.5 to 8.5. Essentially all the groundwater in the study area has pH values within the prescribed PSQCA and WHO criteria. Somewhat low pH values occur in north-western and eastern parts of the aquifer. Slightly higher groundwater pH was found in Ravi Town.

Turbidity pertains to water cloudiness or the level of pellucidity. High turbidity reflects an abundance of impurities, which may be due to silt, plant fibers, microorganisms, wood ash, sawdust, coal dust or chemicals. Ideally, turbidity must less than 1NTU because higher values indicate health risks due to bacterial contamination (Adams, 2001). Turbidity levels should be less than 5 NTU based on WHO standards or less than 0.5 NTU based on PSQCA criteria. Only one of the analyzed water sample had turbidity within PSQCA criteria 0.5 NTU (Fig. 3), thus most of the water in the study area is safe for drinking and domestic purposes according to WHO. Figure 2 E indicates that 100% of the groundwater meets WHO standards for drinking water, whereas only 6.25% qualifies based on the PSQCA limits.

Conductance indicates the water's ability to conduct an electrical current. It shows presence of various dissolved minerals in the water, good quality water contains very low conductance value whereas seawater or rainwater have high conductance. Its value is higher in whole study area especially near river and landfill sites. Test results of conductance can identify water pollution. The health effects of high conductance water depend on type of dissolved solids present in the water. Water may have an unpleasant taste or odor or could even cause an upset stomach. Conductance can be high due to a number of different factors such as; rock and soil (certain minerals), acid mine drainage (dissolved solids copper and iron), agricultural runoff (nitrates and phosphates) and road runoff (salts and other chemicals).

Overall, values of most parameters are within acceptable range of WHO criteria, except arsenic, while four parameters showed more concentration as described in PSQCA standard.

Current study has verified that groundwater is continuously receiving toxic pollutants, therefore groundwater need to some treatment before use especially for drinking and domestic. It is expected that groundwater quality in whole study area is affected from contamination sources especially unplanned landfill sites. There are various studies about groundwater quality of Lahore city were cited in a newspapers report in 2008, all studies showed that water resources are contaminated and unfit for drinking.

According to Daily newspaper (20 May, 2008), United Nations Environmental Programme (UNEP)'s reported that about 47% drinking water in Lahore city was contaminated due to presence of various hazardous toxic elements. A non-governmental organization (Al-Khidmat Foundation) conducted an investigation to compare bacteriological quality of groundwater and found 37.2% groundwater contaminated. During study they were collected water samples from 539 different parts of city in which most developed area Gulberg showed 64% water samples contamination, 57.1% in Multan Road and Shadbagharea with 56.4% (Manan, 2008).

Landfill impacts on groundwater: The most typical detrimental effect of landfill leachate discharge into the environment is groundwater pollution. It is difficult to restore contaminated groundwater resources. Generally, the health of residents is badly affected as low quality water from polluted stretches of river invades the aquifer, leading to high pollution levels of potable water (Dhakyanaika and Kumara, 2010). Communities with poor sanitation and contaminated water supply are at the risk of acquiring waterborne infections like hepatitis A and E, cholera, diarrhea, dysentery, typhoid and parasitic diseases (Saeed and Bahzad, 2006). "Waterborne diseases are common and no water lines meet the World Health Organization standards" is stated after a series of studies conducted in Lahore (WHO, 2004). A recent report indicated that 100% of water samples collected from injector pumps installed at shallow depths of 120 to 150 feet were polluted with *E. coli* due to the intrusion of sewage water in Lahore city (Ahmad *et al*., 2012). The management situation is the worst problem but none of the authorities seems to be moved by the plight of people who are facing different kinds of ailments including tuberculosis, gastro-intestinal problems, asthma, dysfunctional lungs, different types of cancers and other deadly diseases due to the pollution.

The impacts of untreated polluted industrial and municipal waste disposal are posing health risks not only to the city dwellers but also to surrounding communities within the catchments of the Ravi River. A survey done by the Environment Protection Agency (EPA) earlier in year 2008 found that water supplied by the WASA to 20 localities in Lahore city was highly contaminated and unfit for drinking (Dogar, 2008). The residents of Lahore have already filed a petition against the government for supplying them with arsenic contaminated water; the case is being heard at the Lahore High court. The petitioners claimed that consumption of arsenic containing water from WASA's tube-wells was causing gastrointestinal diseases in children and hepatitis and kidney failure in adults. If the water has been contaminated with soluble or insoluble organic or inorganic materials, a combination of mechanical, chemical and/or biological purification procedures are required to protect the environment from periodic or permanent pollution or damage. It is alarming that a survey conducted by the Institute of Public Health revealed that almost half of the samples of drinking water collected from different parts of Lahore contained faecal contaminations. It is, therefore, not surprising that 250,000 children die in Pakistan each year as a result of diarrheal diseases caused by contaminated water (Dogar, 2008).

CONCLUSION AND RECOMMENDATIONS

Municipal landfills are considered a serious threat to their surrounding urban environments and a great source of pollution especially ground water. The present research was carried out to investigate the current ground water quality and the landfill sites contribution to deteriorate groundwater of study area. From result, it has been confirmed that the pollutants in landfill leachate are also present in groundwater. Groundwater quality is poor near dumping sites as compare to far areas, groundwater chemical analysis results were evaluated WHO and PSQCA drinking water standard, hazards parameters contain higher concentration value as prescribed in both standards e.g., TDS and As. The PSQCA criteria, most of pollutants values were over prescribed limit. Even due to over groundwater exploitation to cope with residents demand, cone has been developed under lying aquifer which is facilitating pollutants to flow towards main business centre area from vicinity areas.

The major findings of the present research are as following:

- Physical composition of solid waste and chemical analysis of landfill leachate is indicated that dumping material is not segregated and waste from various sectors (Municipal, commercial, agricultural and industrial).
- Groundwater and leachate chemical analysis results show the pollutants presents in landfill leachate also part of groundwater system. It can estimate toxic leachate infiltrate towards groundwater.
- Groundwater chemical analysis results is depicted mostly pollutants concentration high near landfill sites. Shallow groundwater resources are totally unfit for domestic use, while deep aquifer water also needs treatment before use. Above presented results is showing deep aquifer water quality condition.

The following are some suggestions to protect environment and groundwater quality:

- Unorganized dumping activities, municipal, industrial and agricultural effluents are infiltrated various toxic pollutants towards groundwater; therefore it can expect in future groundwater will be unfit for drinking and many other uses. Authorities must realize environmental hazards and play a vital role to protect and prevent especially groundwater resources by enforces environmental laws.
- Government should promote solid wastes segregation, operational staff training and general public awareness. Also landfill sites must regulate under government and environmental department supervision.
- Groundwater monitoring system must install to observe contamination level. For urban water supply filtration plants should install in whole area and also educate public about precautions measurements such as boiling water, chlorination etc.

It can be concluded that the ill practices of waste management carried out at landfill sites and the absence of leachate collection system has a great impact on the ground water quality of local aquifer. It is strongly suggested that the concerned authorities should take serious steps for the control of ground water pollution and for the safety of local environment and public health as well through improved techniques of solid waste management, leachate collection and ground water monitoring on regular basis.

REFERENCES

Abu-Rukah, Y. and O. Al-Kofahi, 2001. The assessment of the effect of landfill leachate on ground-water quality-a case study: El-Akader landfill site-north Jordan. J. Arid Environ., 49: 615-630.

Adams, V.D., 2001. Water Quality: Protecting Household Drinking Water. (Interpreting a Mineral Analysis). Retrieved from: http://animal range xten sion.montana.edu/LoL/Module-3b/3-Mineral2.htm.

Ahmad, S.R., M.S. Khan, A.Q. Khan, S. Ghazi and S. Ali, 2012. Sewage water intrusion in the groundwater of Lahore, its causes and protections. Pak. J. Nutr., 11(5): 484-488.

Akinbile, C.O. and M.S. Yusoff, 2011. Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. Int. J. Environ. Sci. Dev., 2: 81-89.

Balakrishnan, P., A. Saleem and N. Mallikarjun, 2011. Groundwater quality mapping using Geographic Information System (GIS): A case study of Gulbarga City, Karnataka, India. Afr. J. Environ. Sci. Technol., 5: 1069-1084.

Batool, S.A. and M.N. Chuadhry, 2009. The impact of municipal solid waste treatment methods on greenhouse gas emissions in Lahore, Pakistan. Waste Manage., 29: 63-69.

Butt, I. and A. Ghaffar, 2012. Groundwater quality assessment near Mehmood Boti landfill, Lahore, Pakistan. Asian J. Soc. Sci. Human., 1(2): 13-24.

Dhakyanaika, K. and P. Kumara, 2010. Effects of pollution in River Krishni on hand pump water quality. J. Eng. Sci. Technol. Rev., 3: 14-22.

Dogar, B., 2008. Lahore: 20 Localities Getting Contaminated Water. Newspaper “The Nations”, Retrieved from: http://www.lahorerealestate. com/ pakreale state times/showthread. php? tid = 413.

Energy Sector Management Assistance Program (ESMAP), 2010. Good Practices in City Energy Efficiency, Lahore, Pakistan: Solid Waste Composting. Retrieved from: http://www. esmap. org/node/658.

Farooqi, A., H. Masuda and N. Firdous, 2007. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environ. Pollut., 145: 839-849.

Hari Haran, A., 2002. Evaluation of drinking water quality at Jalaripeta village of Visakhapatnam district Andhra Pradesh. Nat. Environ. Pollut. Technol., 1(4).

Hayder, S., H. Haider, A. Bari and A. Faragh, 2012. Effect of Mehmood Booti dumping site in Lahore on ground water quality. Pak. J. Eng. Appl. Sci., 10: 51-56.

Jain, C., K. Bhatia and T. Vijay, 1995. Ground water quality monitoring and evaluation in and around Kakinada Andhra Pradesh. Technical Report, CS (AR)172, National Institute of Hydrology, Roorkee.

Jhamnani, B. and S. Singh, 2009. Groundwater contamination due to Bhalaswa landfill site in New Delhi. Int. J. Environ. Sci. Eng., 1: 121-125.

Joseph, K., 2004. A cleaner production approach for minimization of total dissolved solid in reactive dying effluents. Centre for Environmental Studies, Anna University, Chennai.

Karim, S., 2010. Impact of solid waste leachate on groundwater and surface water quality. J. Chem. Soc. Pak., 32(5).

Kendall, P., 1992. Newsletter in Drinking water quality and health. Pat Kendall, Colorado State University.

Lahore CDG, 2007. Solid Waste Management Plan 2007-2021. Lahore, Pakistan.

Longe, E. and M. Balogun, 2010. Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. Res. J. Appl. Sci. Eng. Technol., 2: 39-44.

Manan, A., 2008. E coli Affecting Groundwater Quality. Newspaper "The Daily Time". Retrieved from: http://www.dailytimes.com.pk/ default. asp? page=2008%5C05%5C20%5Cstory_20-5-2008_ pg7_42.

Misra, V. and S. Pandey, 2005. Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. Environ. Int., 31: 417-431.

Mor, S., K. Ravindra, R.P. Dahiya and A. Chandra, 2006. Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environ. Monit. Assess., 118(1-3): 435-56.

Murtaza, G. and A. Rahman, 2000. Solid Waste Management in Khulna City and a Case Study of a CBO: Amader Paribartan. In: Maqsood Sinha, A.H.Md. and I. Enayetullah (Eds.), Community Based Solid Waste Management: The Asian Experience. Waste Concern, Dhaka, Bangladesh.

Naeem, M., K. Khan, S. Rehman and J. Iqbal, 2007. Environmental assessment of ground water quality of Lahore area, Punjab, Pakistan. J. Appl. Sci., 7: 41-46.

PSQCA, 2004. Pakistan standards specification of bottled drinking water (3rd Revision), PS: 46392004 (R), under compulsory certification marks scheme. Pakistan Standards and Quality Control Authority, Ministry of Science and Technology, Government of Pakistan, Islamabad, Pakistan.

Saeed, M. and A. Bahzad, 2006. Simulation of contaminant transport to mitigate environmental effects of wastewater in river Ravi. Pak. J. Water Resour., 10(2).

Sandulescu, E., 2004. The contribution of waste management to the reduction of greenhouse gas emissions with applications in the city of Bucharest. Waste Manage. Res., 22: 413-426.

Słomczyńska, B. and T. Słomczyński, 2004. Physico-chemical and toxicological characteristics of leachates from MSW landfills. Pol. J. Environ. Stud., 13: 627-637.

Smith, W. and I. Crombir, 1987. Chronic heart diseases and water hardness. J. Epidemiol. Commun. Health, 41(3): 227-228.

Sohani, D., S. Pande and V. Srivastava, 2001. Ground water quality at Tribal Town: Nandurbar (Maha rashtra). Indian J. Environ. Ecoplan., 5: 475-479.

Subba, R.N., 1998. Groundwater quality in crystalline terrain of Guntur district andhra Pradesh. Visakha Sci. J., 2: 51-54.

Tchobangoglous, G.T.H. and S. Vigil, 1993. Integrated Solid Waste Management; Engineering Principles and Management Issues. Mc-Graw Hill, USA.

The British Columbia GWA, 2007. Hardness in Groundwater. Retrieved from: http://www. Hamil tonma.gov/Pages/HamiltonMA_Water/Hardness% 20The%20British%20Columbia%20Groundwater %20Association[1].pdf.

USEPA, 1993. A review of methods for assessing aquifer sensitivity and ground water Vulnerability to pesticide contamination. Vol. U.S. EPS. EPA/813/R-93/002.

Vasanthi, P., S. Kaliappan and R. Srinivasaraghavan, 2008. Impact of poor solid waste management on ground water. Environ. Monit. Assess., 143: 227-238.

WHO, 2004. Guidelines for Drinking-Water Quality. Vol. 1, Recommendations. World Health Organization, Geneva.

Woodard, R., M. Bench, M.K. Harder and N. Stantzos, 2004. The optimisation of household waste recycling centres for increased recyclingâ€" A case study in Sussex, UK. Resour. Conserv. Recy., 43: 75-93.

Younas, M.A.S., I.H. Jaffery and M. Farooq, 1999. Forms of Cd, Pb, Zn and Crincontamination soils from Raiwind, Lahore, Pakistan. J. Chem. Soc. Pak., 21: 393-399.