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Impact of municipal solid waste on groundwater quality in Jhang City Punjab, Pakistan

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Key words: Solid waste, Ground water quality, Dumping sites, Geographic information system (GIS), Jhang

Abstract

The current study was carried out to investigate the impact of solid waste dumping sites on ground water quality in Jhang city, Pakistan. In order to investigate the solid waste disposal effects on ground water quality, the study area has been divided into two parts i.e solid waste sites and controlled area. Ground water is the major source of drinking water in study area. Therefore, water samples have been collected near and surrounding the municipal solid waste dumping sites and analyzed for various parameters of water quality. These results showed that TDS found high (75%), CE (90%), Chloride (35%), Hardness (60%), Alkalinity (25%) and calcium (30%) respectively. The water condition in controlled area was much stable and 90% of samples results in limits as per WHO purposed values of parameters. Detailed maps were produced to elaborate ground water quality in different areas of study through Geographic Information System (GIS). Current study concluded that the high concentration of physiochemical parameters of ground water was present in dump sites surrounding samples indicate the poor water quality which is not fit for drinking purpose.

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Introduction

Ground water pollution has become a great problem and emerged as the most crucial environmental issues for the last two decades (Kamboj & Choudhary, 2013). Water is an essential component of all living being on earth surface (Riaz *et al.*, 2017). Availability of clean water for drinking purpose is requirement and sign of healthy society (Kendall, 1992). Water resources are facing stress and complicated situation all over the world. Ground water quality has been degraded due to disposal of untreated waste water from solid waste, industries, urban runoff and agricultural activities (Jain *et al*, 1995) especially in small urban areas where no proper solid waste dumping methods have been adopted (Megda *et al.*, 2015). According to Haider (2012) high population growth, poor sanitation facilities, rapid urbanization and unplanned solid waste dumping have great effect on water quality and quantity. Increasing population in developing cities and its increasing waste have started degrading the environment specially groundwater quality (Rahman, 1996; Riaz *et al.*, 2016). Globally, municipal solid waste dumping and associated activities have a lot of challenges in developing nations with highly dense population (Sadek and El-Fadel, 2000).

Worldwide, open solid waste dumping is the oldest method and the easiest way to manage the solid waste (Jhamnani and Singh 2009) although such methods are still being used and have adverse effects on groundwater (Longe and Balogun, 2010). Pollution through solid waste sites increases especially in rainy season due to the percolation of rainwater from solid waste to groundwater (Christonsen and Kjeldsen, 1989). Poorly managed solid waste sites contaminate groundwater which directly impacts the human health. Such phenomenon occurs in small cities of both Pakistan and India (Rajkumar *et al.*, 2010). According to Jaint *et al.*, (1995) leaching process varies due to temperature, hydrology of site, waste collection duration, material composition and its decomposition. Waste production in urban areas is alarming which leads to contamination of groundwater. Untreated, improper and unplanned dumping techniques have been used for the solid waste especially in developing countries.

Numbers of studies have been conducted throughout the world to assess the groundwater quality and landfill sites impact by using different approaches and methodologies. Many researchers (Longe and Balogon, 2010; Abu-Rukh and al- Kofahi, 2001 Vasanthi *et al.*, 2008; Jaint *et al.*, 1995; Karim *et al.*, 2010; Megda *et al.*, 2015) have determined the solid waste disposal impact on groundwater quality and explored that land fill sites are the key contributing factors to degrade the water quality as well as surrounding communities' environment. Awareness about the solid waste management is necessary to reduce the harmful impact of solid waste on groundwater quality (Enekwechi and Longe, 2007). Keeping above in view, this study was conducted on the ground water quality of Jhang city area in the surroundings of municipal solid waste dumping sites and compared with places located at the outstrip from such dumping sites.

Material and method

Study Area

Jhang is situated between 31°-15′ and 31°-17′ North latitudes and 72°-18′ and 72°-22′ East longitudes with an elevation of 679 feet above sea level (JCP, 1998). Jhang is the old traditional settlement having its own culture and is giving the services to its 2834545 inhabitants according to 1998 census of Pakistan (PBS, 1998). Study area is facing generally hot type of climate and having the maximum temperature in June 48.8°C and minimum temperature in January is 12.3°C. The whole region is situated in Monsoon (Am) type of climate according to Kopan's classification of climate around the globe and annual rainfall is 248mm (CJS, 2016).

In order to investigate the solid waste disposal effects on ground water quality, the study area has been divided into two parts. The name of the study area parts were Yousuf Shah Road site, Purana Chiniot road site due to presence of solid waste in these locations and a controlled area. 20 ground water samples were collected around the solid waste dumping sites (10 from each site) and 20 from controlled area.

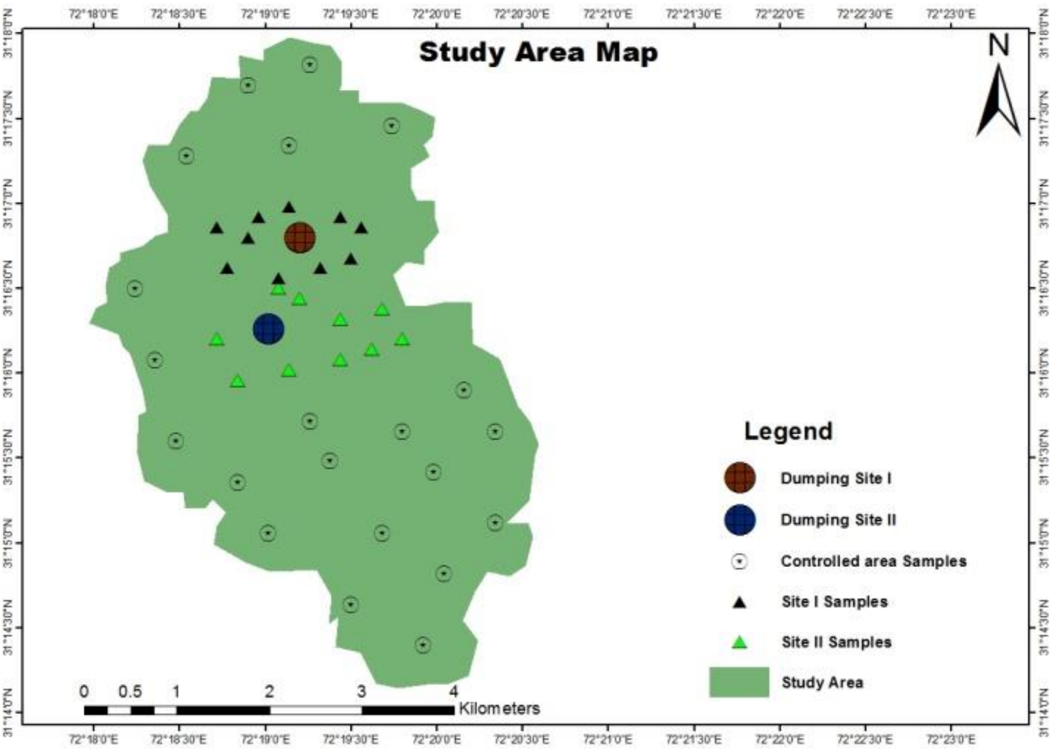

Fig. 1. Study Area Map.

In this way 20 ground water samples results were used to compare and contrast of contamination potential of dumping site with controlled area results. Samples of drinking water were collected from randomly selective location in sterilized screw caped glass bottles as per the sampling standard.

The collected samples were labeled with code, date and their locations. All samples were brought to laboratory and analyzed the various physiochemical parameters like; Total dissolved solid, conductivity, arsenic, sodium, chloride, magnesium, total hardness, alkalinity, potassium and turbidity.

Results and discussion

Table 1. Detailed results and mean values of solid waste dumping sites water samples.

Location	Temperature	pH	TDS	N.T.U	Alkalinity	Ca	Magnesium	Hardness	Chloride	EC	Arsenic
PR 1	16.7	7.3	1530	4.11	449	132	50	530	162.4	2250	0.01
PR 2	16.9	7.1	2137	4.46	683	218	32.5	550	321.6	3143	0.01
PR 3	16.2	6.9	1459	7.07	768	160	67.5	670	296.8	2146	0.03
PR 4	16.0	7.7	833	2.32	640	184	60	700	311.8	1225	0.01
PR 5	16.4	7.3	997	2.19	726	64	55	380	151.6	1466	0.01
PR 6	16.5	7.3	2404	2.44	510	228	75	650	172.8	3535	0.005
PR 7	16.2	6.8	2027	4.04	472	220	52.5	510	197.2	2981	0.003
PR 8	16.8	7.8	1789	11.6	340	216	100	540	206.6	2631	0.02
PR 9	16.6	7.6	1931	2.44	490	192	12.5	280	98.6	2840	0.01
PR 10	16.3	7.3	1681	2.21	653	202	42.5	590	284.2	2472	0.004
YR 1	16.7	7.1	1153	2.16	540	164	40	570	266.8	1696	0.01
YR 2	16.4	7.8	654	2.49	401	124	65	570	249.4	962	0.02
YR 3	16.9	7.5	1745	4.29	417	116	50	490	226.2	2566	0.006
YR 4	16.8	7.3	1105	4.12	428	80	42	380	191.4	1625	0.004
YR 5	16.1	7.1	784	2.10	394	80	27.5	310	145	1153	0.002
YR 6	16.3	7.4	1232	3.72	480	200	65	760	249.4	1812	0.01
YR 7	16.5	7.5	1296	2.49	574	100	35	390	116	1906	0.01
YR 8	16.2	7.6	539	4.31	413	116	30	410	220.4	793	0.03
YR 9	16.6	7.6	1094	4.11	341	116	27.5	400	197.2	1608	0.01
YR 10	16.4	7.0	1855	10.11	315	196	72.5	780	338.4	2728	0.002
	16.47	7.35	1412	4.13	501.7	155.4	50.1	523	220.2	2076.9	0.010

Source: Laboratory analysis.

Table 2. Detailed results and mean values of controlled area water samples.

Location	Temperature	pH	TDS	N.T.U	Alkalinity	Ca	Magnesium	Hardness	Chloride	EC	Arsenic
CA1	16.0	7.8	1079	5.97	340	192	30	600	218.4	1587	0.004
CA 2	16.7	7.3	618	4.11	410	160	30	520	371.2	909	0.01
CA 3	16.9	7.2	1996	2.47	353	148	82.5	700	319	2936	0.01
CA 4	16.4	7.3	890	2.21	361	136	52.5	550	168.2	1310	0.01
CA 5	16.8	7.4	909	2.33	271	108	25	370	121.8	1338	0.005
CA 6	16.1	7.5	1133	2.42	337	80	37.5	350	185.6	1667	0.002
CA 7	16.5	6.8	976	2.33	214	104	27.5	370	251	1436	0.006
CA 8	16.3	7.4	811	2.21	395	100	40	410	174	1194	0.004
CA 9	16.6	7.6	845	2.42	324	148	67.5	400	197.2	1243	0.003
CA 10	16.0	7.2	847	2.81	90	60	77.5	700	104.4	1247	0.005
CA 11	16	7.4	1026	2.79	391	148	82.5	700	258.2	1509	001
CA 12	16.9	7.4	422	2.37	358	56	50	340	156.6	621	0.004
CA 13	16.7	7.6	561	2.05	286	240	17.5	170	159.5	826	0.007
CA 14	16.1	7.5	726	2.47	377	56	42.5	330	179.8	1068	0.003
CA 15	16.4	7.7	1394	3.42	311	40	47.5	290	98.6	2050	0.002
CA 16	16.8	7.6	569	3.32	319	104	50	760	139.2	837	0.005
CA 17	16.5	7.3	1048	1.82	268	64	42.5	330	133.4	1542	0.003
CA 18	16.3	7.2	777	0.71	354	60	25	250	205.5	1144	0.01
CA 19	16.9	7.2	795	2.24	130	140	35	490	272.6	1170	0.006
CA 20	16.6	7.5	851	4.11	341	164	15	720	187.2	1252	0.003
Mean	16.47	7.4	913.65	2.72	311.5	115.4	43.87	476.5	195.07	1344.3	0.055

Source: Laboratory analysis.

Water test were performed in District Water Testing Laboratory, Public Health Engineering Department Jhang according to WHO standards. All the mean values of temperature in 40 groundwater samples are shown in table 1, 2 and Fig. 2. Temperature of water samples was according to the temperature of land in the months of February and March which ranges from 16 to 16.9° degree Celsius. The highest temperature in study area is 16.9° C while the lowest is 16.0° C in different locations. pH is the measurement of basic quality of water as it is acid or alkaline and neutral pH value is 7 (Hayder *et al.*, 2009). The values of pH in study area samples sites are shown in table 1 & 2 and Fig. 3. The WHO recommended value of pH is 6.5 to 8.5. pH values varied between 7.8 to 6.8. Study results shows that 100% samples of groundwater from both study area parts were in limit as compared to WHO permissible limit.

The overall value of TDS in water samples are shown in table 1 & 2 and Fig. 4. The WHO recommended value of TDS in drinking water is 1000 ppm. The highest TDS value of 2404 mg/l is found at (PR 6) sampling site. In dumping site area 75% of groundwater samples have high concentration of TDS and 05 only 25% were within the permissible limits while 70% samples of control area were within limit according to the WHO recommendations. According to evaluation the overall values of EC are shown in table 1 & 2 and Fig. 5. The WHO recommended value of EC is 1000 µs/cm. EC values varied between 794µs/cm to 3536µs/cm in sampling sites of the study area. Only 10% of groundwater samples of dumping site area were in limit while remaining 90% have high value of EC. Study results shows that water quality condition in controlled area is better and 95% samples were found in limit. The highest EC values were recorded at PR 6 sampling site.

In drinking water Calcium is essential part for human body, on the other hand its deficiency causes weakening of it (WHO, 2004). The overall mean values of calcium are shown in table 1 & 2 and Fig. 6. Calcium concentration record during the course of study was 228 mg/l, highest at PR 6 while the lowest 64 mg/l at PR 5.

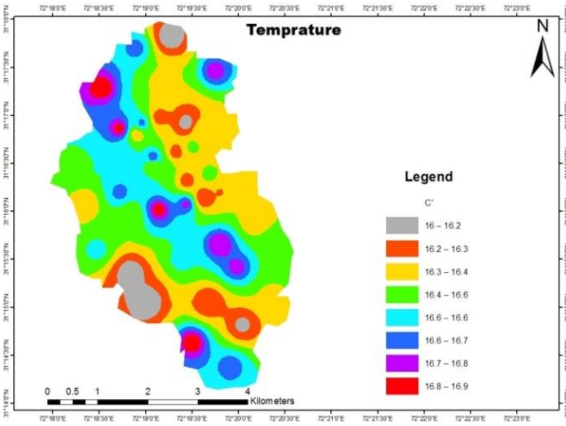

Fig. 2. Concentration of Temperature.

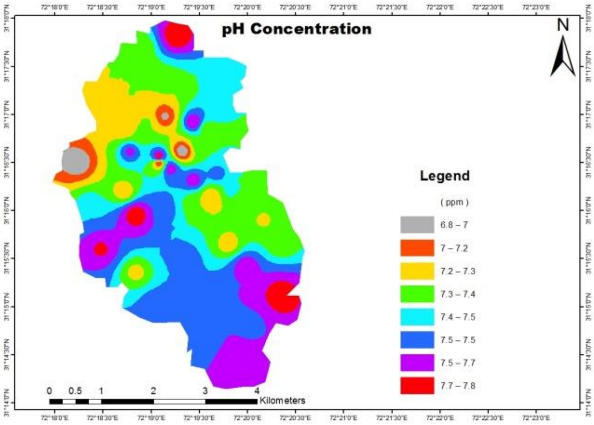

Fig. 3. Concentration of pH.

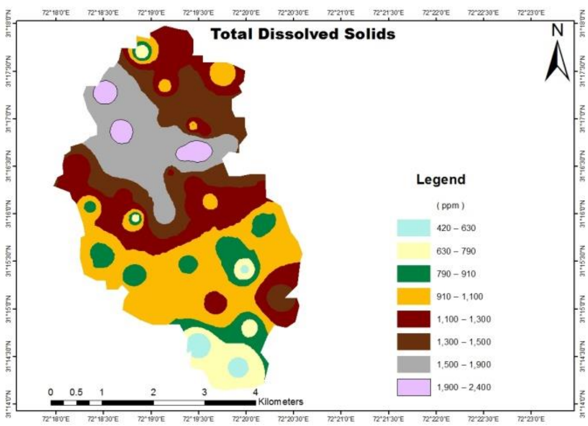

Fig. 4. Concentration of TDS.

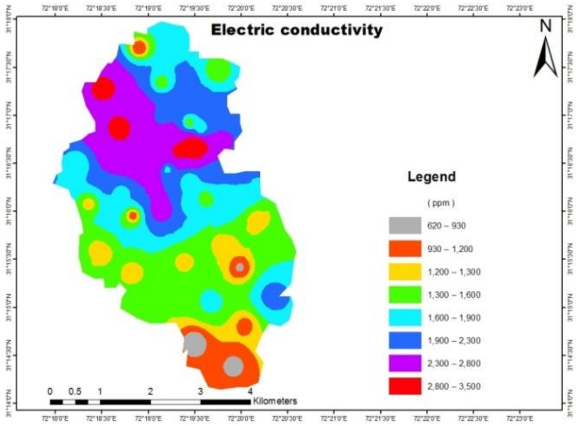

Fig. 5. Concentration of EC.

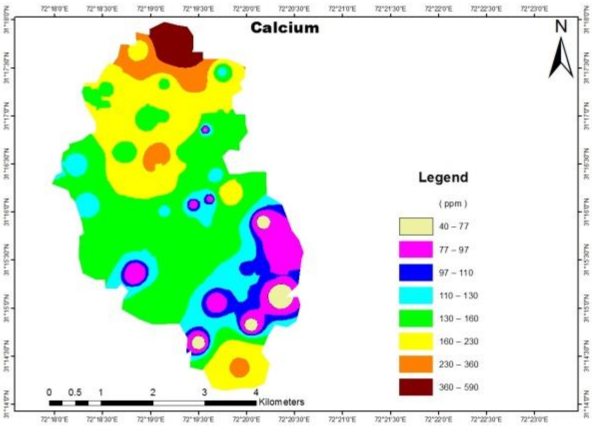

Fig. 6. Concentration of Calcium.

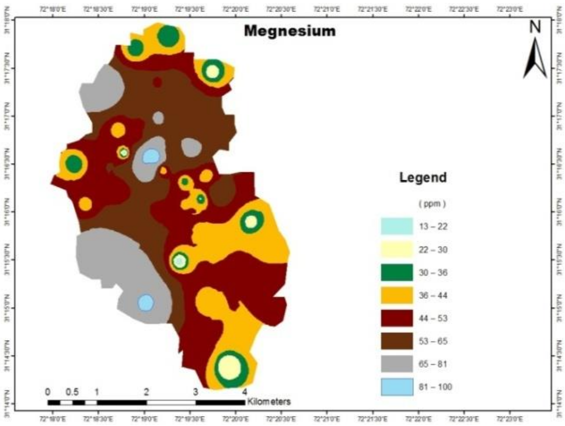

Fig. 7. Concentration of Magnesium.

The permissible limit of WHO for Calcium is 75ppm to 200ppm. In this study 70% water samples of dumping site area were in limits while 30% samples have high concentration as compared to WHO recommended values. Water quality condition in controlled area is much better and 95 % water samples were in limit.

All the mean values of magnesium are shown in table 1 & 2 and Fig. 7. Magnesium is essential part of body because 25g of Magnesium is present in human body including bones and tissues (WHO, 2004). WHO recommended value of Magnesium is 150mg/l. The magnesium maximum concentrations were found 100mg/l at PR8 while minimum 12.5 mg/l at PR9. The results shows that 100% water samples of both study area parts were remain in permissible limits of Magnesium by WHO. Chloride in groundwater added through solid waste and sewage.

Its maximum concentration should not be exceeded 250mg/l. It is important for metabolism activity in human body (WHO, 2004). The overall evaluated concentrations of chloride in drinking water of selective locations are shown in table1& 2 and Fig. 8. Almost 35% of groundwater samples have high concentration of Cl while remaining 65 % sampling of dumping site area have controlled Chloride limits. Control area water quality is better and 90% samples were in limits as compared to WHO permissible limits.

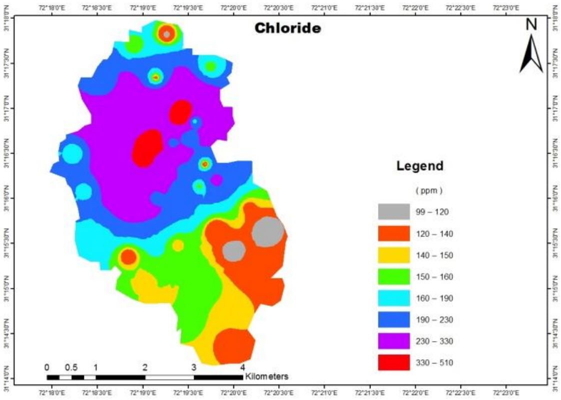

Fig. 8. Concentration of chloride.

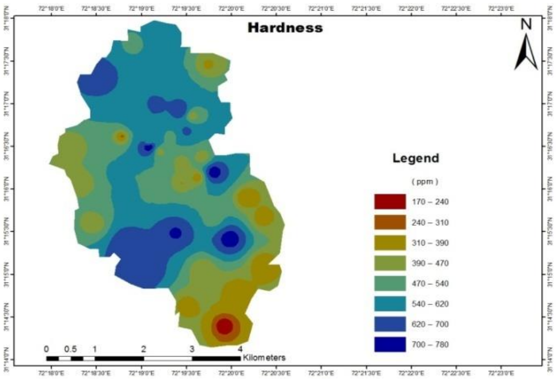

Fig. 9. Concentration of Hardness.

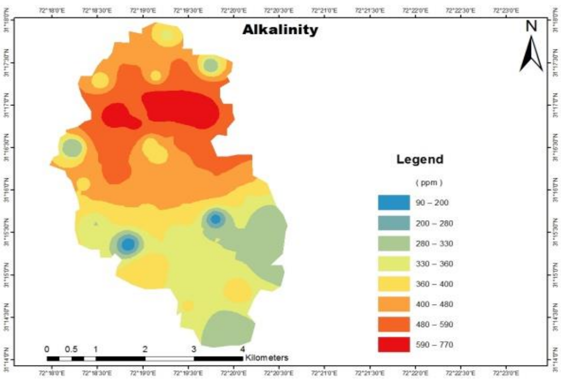

Fig. 10. Concentration of Alkalinity.

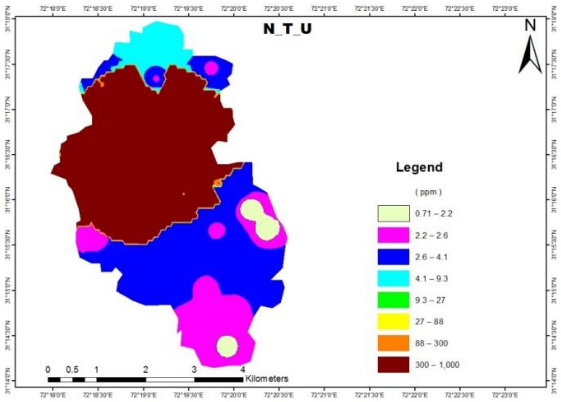

Fig. 11. Concentration of Turbidity.

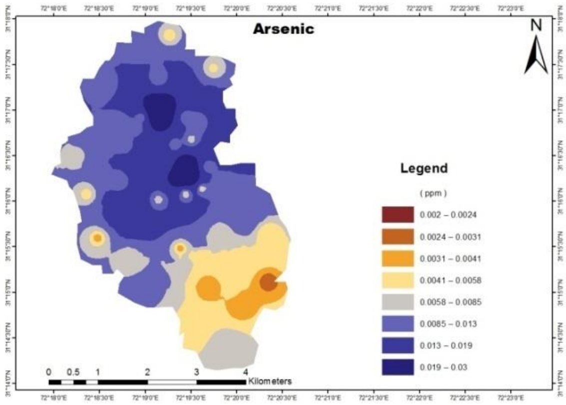

Fig. 12. Concentration of Arsenic.

The WHO recommended value of Hardness is 500mg/l. All the evaluated values of Hardness are shown in table 1 & and Fig. 9. Its values varied from 380 mg/l at PR5 to 780 mg/l at PR 10. In study area 60% of groundwater samples were out of limit according to the WHO permissible limits while remaining 40% were in limit. Controlled area samples results show 65% samples were in limits. The over all mean values of alkalinity are shown in table 1 & 2 and Fig. 10. The WHO recommended value of Alkalinity is 200mg/l to 600mg/l. Alkalinity values varied from 315mg/l to 768mg/l. Only 25% water sample of near dump site localities have high concentration of alkalinity and remaining 75% were within limit according to the WHO. In controlled area all 100% water samples were in limit.

Turbidity is a measurement of suspended solids in water. Suspension of different type of material makes water turbid (Baswijnen *et al.*, 2011). All the mean concentrations of turbidity are shown in table 1 & 2 and Fig. 11.

The WHO recommended value of Turbidity is <5 NTU. Turbidity values varied from 2.16 NTU to 11.68 NTU. In dumping site area 10% water samples have high concentration of Turbidity while remaining 80% have permissible limits according to the WHO. All the samples of controlled area were in limit. Overall evaluated values of arsenic are shown in table 1 & 2 and Fig. 12. Arsenic concentration in water is harmful for humans especially kidneys. It is also harmful for nervous system and can cause cancer. Arsenic is tasteless, odorless and colorless which is difficult to detect (Kahlown *et al.*, 2003). Its recommended limit in drinking water is 10µg/l by the WHO (Flanagan *et al.*, 2012). All the samples values of arsenic in both parts of study area were in limit as compared to WHO permissible limits.

Conclusion

It was concluded that the dumping sites in Jhang city were contaminating the ground water through leaching. Current study revealed that the high concentration of TDS (75%), CE (90%), Chloride (35%), Hardness (60%), Alkalinity (25%) and calcium (30%) were found near dumping sites of Purana Chiniot Road and Yusuf Shah Road. Water quality condition is worse especially in Purana Chiniot road (PR) sampling site area due to solid waste as well as sewage water. Though, situation is much better in controlled area where maximum water samples were in permissible limits. So, there is time to make scientific measurement of Municipal Solid Waste (MSW) dumping sites and surrounding areas to prevent ground water contamination. Therefore, proper management and monitoring system has been required to cope with this phenomenon.

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