Studies on Physico-Chemical Nature of Ground water of Korangi/Landhi (Karachi)

S. NAEEM MAHMOOD, SITWAT NAEEM, ISHRATULLAH SIDDIQUI AND FAROOQ AHMED KHAN
PCSIR Laboratories Complex,
Off Univesity Road, Karachi-75280, Pakistan

(Received 20th April, 1996, revised 17th December, 1996)

Summary: 65 water samples collected from wells, handpumps, and borings, have been analysed to assess the quality of ground water of Korangi/Landhi (Karachi). Large variations in the levels of various physico-chemical parameters and major chemical constituents, among the samples collected from different localities of the area, have been observed. Possible causes of the changes in chemical composition of the water have been identified and discussed. Seepage of domestic and industrial waste water and sea water intrusion seem to be the main sources of contamination of ground water. The quality of the water has also been compared to that of some major cities of Pakistan. The chemical composition of the ground water has been substantially deteriorated and the water as such is not suitable for human consumption as well as general industrial use.

Introduction

The shortage of water in Karachi city, due to rapid increase in population and industrial activity, has forced the people to meet their requirements from ground sources viz. wells, borings and handpumps. In Korangi/Landhi area alone, more than four thousand well, borings, or handpumps are being used to draw water. Korangi Industrial Area (KIA) and Landhi Industrial Area (LIA) are also located in the area under study where a large number of small and medium size industrial units are concentrated. The scarcity of water has also forced many industrial units of KIA and LIA to have dug wells or boreholes on their premises as a dependable source of water.

Although a large population is using ground water, no scientific evaluation of the quality of ground water of Karachi city and its neighbourhood, has been under taken. The present investigation deals with physico-chemical parameters and quantitative chemical analysis of the ground/well waters of Korangi/Landhi area to determine their suitability for human consumption and industrial use. Characteristics of the waters in terms of the variation of their chemical constituents viz. Ca, Mg, Na, K, Cl, SO_4, NO_3, CO_3 and HCO_3 have been discussed and the waters have been classified according to their ionic composition. This study is intended to serve as a data base of the ground water quality of Korangi/Landhi area for future comparison of any hydrogeological changes to help water engineers and scientists in planning and future extrapolations. The basic data on chemical composition of the ground water of Korangi/ Landhi area could also be used for employing a viable physico-chemical process to obtain the water of desired purity.

Results and Discussion

Fig. 1 shows the levels whereas Table-1 shows the ranges and mean values of the physico-chemical parameters of the analysed samples. Except for six samples i.e. sample Nos. 29, 30, 36, 56, 61 and 65 which have <7.0 pH, all the samples show more than 7.0 pH, indicating that they are weakly alkaline waters.

Total alkalinity of the samples is mostly bicarbonate alkalinity, whereas carbonate alkalinity is present in only 3 samples (sample Nos. 13, 18 and 44) but that also is very low in concentration.

Ground water of the area is generally very hard 26 samples out of 65 (40 %) contain total hardness levels of more than 500 mgl^{-1}. Electrical conductivity can be mainly attributed to the dominance of major cations and anions in the ground waters, it is directly proportional to the amount of total dissolved salts [1]. The range of conductivity is alarmingly high (10710 to 18064 μScm^{-1}) in the samples from Korangi Industrial Area (KIA).

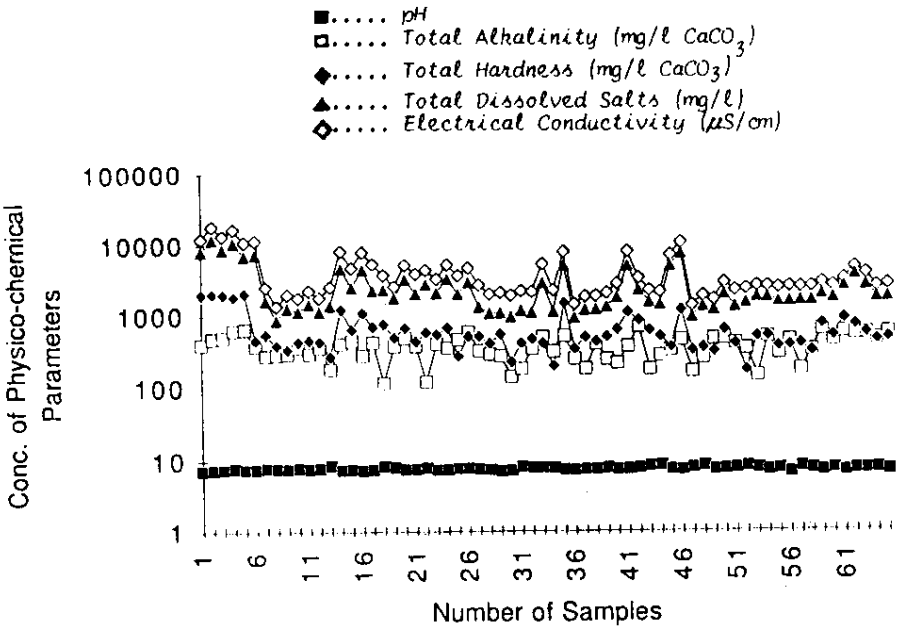

Fig. 1: Levels of physico-chemical parameters in ground water samples of Korangi/Landhi.

Table-1: Physico-chemical parameters* in Korangi/Landhi ground water

Sampling Locations	No. of Samples	pH	Alkalinity (mg^{-1} as $CaCO_3$)	Hardness (mg^{-1} as $CaCO_3$)	EG (μS/cm)	TDS (mgl^{-1})
Korangi Industrial Area (KIA)	6	7.4 (7.1-7.8)	504 (380-644)	1697 (454-2030)	13583 (10710-18064)	8874 (6955-11730)
Korangi Residential Area No.1 (K-1)	7	7.8 (7.5-8.4)	294 (180-360)	407 (268-541)	2006 (1342-2562)	1259 (872-1632)
Korangi Residential Area No. 2 (K-2)	5	7.8 (7.2-8.3)	331 (115-440)	861 (629-1180)	5834 (3654-7940)	3177 (2218-4526)
Korangi Residential Area No. 3 (K-3)	6	7.5 (7.3-7.9)	349 (120-480)	554 (430-654)	3989 (2523-5102)	2470 (1717-3230)
Korangi Residential Area No. 4 (K-4)	8	7.5 (6.9-8.0)	335 (140-580)	365 (224-499)	2584 (1829-4563)	1417 (942-2852)
Korangi Residential Area No. 5 (K-5)	6	7.5 (7.2-7.8)	353 (180-500)	540 (193-1409)	3279 (2144-7497)	1987 (894-4868)
Korangi Residential Area No. 6 (K-6)	6	7.7 (7.3-8.2)	320 (173-662)	671 (484-1041)	3229 (1952-7536)	2114 (1268-4770)
Ibrahim Haidery (IH)	2	7.2 (7.1-7.3)	378 (320-435)	732 (350-1113)	8228 (6615-9840)	5902 (4725-7079)
Landhi Residential Area (L-1 to L-6)	15	7.3 (6.5-8.1)	358 (139-590)	431 (166-823)	2222 (1284-2936)	1254 (914-2350)
Landhi Industrial Area (LIA)	4	7.1 (6.8-7.3)	479 (436-523)	520 (420-679)	3115 (2290-4258)	2269 (1615-3426)

*Extreme values (Lowest and highest) are within parentheses; mean value is outside.

TDS (Total Dissolved Solids) in ground waters from residential areas show a higher tendency in general. Only five samples i.e. Sample Nos. 8, 12, 30, 36 and 47 have a TDS below 1000 mgl^{-1} and rest of the samples (92.4%) contain more than 1000 mgl^{-1} TDS. All the samples from KIA (Sample Nos. 1 to 6) and sample no. 47 from Ibrahim Haidery, have TDS levels of more than 7,000 mgl^{-1}. Samples collected from the areas which are relatively close to Korangi/Landhi Industrial Area show higher levels of TDS than that of other residential areas.

Figs 2 and 3 show the concentration of anions and cations whereas Table-2 shows the

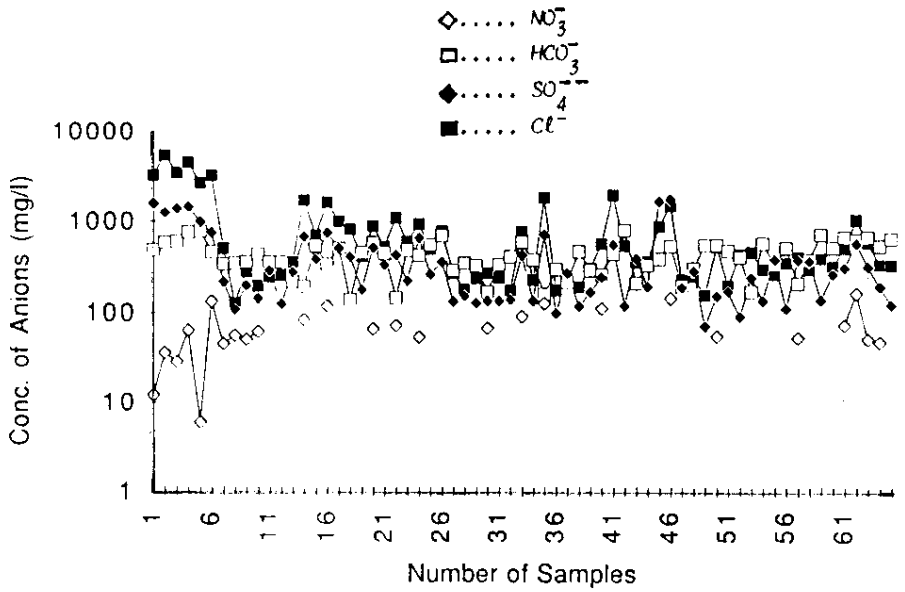

Fig. 2: Concentration of anions in ground water samples of Korangi/Landhi.

Table-2: Concentration* of cations and anions in Korangi/Landhi water

Sampling Locations	Chloride (mgl^{-1})	Bicarbonate (mgl^{-1})	Sulphate (mgl^{-1})	Nitrate (mgl^{-1})	Calcium (mgl^{-1})	Magnesium (mgl^{-1})	Sodium (mgl^{-1})	Potassium (mgl^{-1})
KIA	3736	612	1232	47	154	319	2404	37
	(2682-5400)	(463-786)	(749-1578)	(6-133)	(45-208)	(83-396)	(1535-3499)	(12-51)
K-1	281	346	194	54	72	47	222	27
	(126-504)	(220-440)	(109-290)	(46-63)	(36-108)	(36-78)	(100-340)	(13-43)
K-2	1179	404	549	102	132	131	760	30
	(707-1721)	(140-537)	(385-754)	(85-120)	(78-197)	(69-189)	(418-1050)	(17-52)
K-3	747	426	392	71	89	81	565	36
	(413-1099)	(146-586)	(178-666)	(68-74)	(60-118)	(57-105)	(310-760)	(17-62)
K-4	333	408	183	62	68	47	287	30
	(176-780)	(171-708)	(134-362)	(55-69)	(32-111)	(31-86)	(120-750)	(8-62)
K-5	578	429	296	110	78	84	434	20
	(177-1844)	(200-610)	(100-720)	(92-128)	(18-132)	(36-262)	(108-1175)	(9-40)
K-6	679	390	278	57	104	97	417	30
	(305-1962)	(211-807)	(120-553)	(10-113)	(32-226)	(40-169)	(170-1250)	(12-50)
IH	1190	463	1707	120	157	83	1900	225
	(879-1500)	(390-536)	(1670-1744)	(95-145)	(94-220)	(28-137)	(1350-2450)	(140-310)
L-1 to	337	437	218	61	87	53	302	21
L-6	156-532)	(170-719)	(91-374)	(54-74)	(19-184)	(22-120)	(174-405)	(5-45)
LIA	567	614	297	88	82	77	508	23
	(325-1030)	(532-663)	(121-563)	(48-163)	(72-92)	(53-115)	(132-840)	(13-37)

*Extreme values (lowest and highest) are within parentheses, mean value is outside.

ranges and mean values of the anions and cations in the water samples.

It would be observed from Fig. 2 and Table-2 that chloride is the most dominant anion in majority of the samples. Only thirty-four samples (57.6%) contain a concentration less than 500 mgl^{-1} (126 to 400 mgl^{-1}) which is perhaps close to the normal range of chloride content in the ground water of the area under study.

Sodium like chloride is a dominant cation and major contributor to TDS (Fig. 3) 29% of the samples have sodium level of 250 mgl^{-1} whereas 18.4% (mainly from industrial areas) fall within 1050 to 3499 mgl^{-1} range.

Samples from KIA show a higher range (749-1578 mgl^{-1}) of sulphate than that of the samples from residential areas (72-754 mgl^{-1}). Sample Nos. 45 and 46 collected from Ibrahim

Haidery, a locality situated near the sea shore (Fig. 4) contain highest levels of SO_4 (Fig. 2). These samples also have relatively high levels of chemical constituents because of sea water contamination (Table-2).

Bicarbonate is present in all the samples whereas carbonate is found in only three samples i.e. Nos. 13, 18 and 44 ranging between 8-16 mgl^{-1}. Majority of the samples (67.7%) contain bicarbonate ranging between 300 and 600 mgl^{-1}, only 10 samples (15.4%) contain more the 600 mgl^{-1}.

The concentration of calcium ranges from 18 to 226 mgl^{-1}, 39 samples (60%) contain less than 100 mgl^{-1} and 23 samples (35%) between 100 and 200, mgl^{-1}. Only three samples contain more than 200 mgl^{-1} of calcium.

All the samples collected from KIA show significantly higher levels of magnesium (>300 mgl^{-1}) than the samples from other areas under reference (Table-2). 10 samples (15.4%) contain more than 100 mgl^{-1}, whereas 48 samples (73.8) contain less than 100 mgl^{-1} of magnesium.

Potassium is present in relatively small concentration, ranging between 5 and 62 mgl^{-1} (Fig. 3), except for sample Nos. 45 and 46 (from Ibrahim Haidery) which have 140 and 310 mgl^{-1}.

The concentration of NO_3 in the analysed samples ranges between 6 and 163 mgl^{-1}. The relatively higher concentration range of NO_3 (46-163 mgl^{-1}) in the residential area samples than that in the industrial area samples (6-133 mgl^{-1}) clearly indicates contamination of the waters with domestic waste water.

High sodium chloride concentration in the ground water of the area is perhaps due to the presence of sea water entrapped in sediments or solution of halite and related minerals in evaporate deposits [2]. It also suggests that the sedimentary rocks of the area are of marine origin. The generally high calcium and magnesium contents of the water might also be due to abundance of dolomite, magnesite, and calcite in the area [3].

Generally in sedimentary rocks, fresh water are located in siliceous sands and sand stones essentially formed by quartz having ionic composition: Ca>Na>Mg and CO_3 comb. > Cl>SO_4 [4]. Sedimentary rocks also contribute a portion of their soluble constituents to the ground water because of their high solubility as compared with igneous rocks [5]. The typical ionic composition (expressed in mgl^{-1}) of ground/spring waters of Karachi and its neighbourhood is: Na > Mg> Ca> K and Cl > SO_4 > HCO_3 [6]. These are basically carbonate waters under the influence of main sedimentary rocks. Their chemical composition has been changed during circulation due to various factors such as concentration, leaching, sea water intrusion, ion exchange and low rainfall leading to the ultimate ionic composition: Na > Mg > Ca> K and Cl > SO_4 > HCO_3 [6,7]. In some samples Ca exceeds magnesium changing the cationic composition to Na > Ca > Mg > K possibly due to excessive calcite or gypsum.

In the two industrial estates of the area the two dominating industries viz. textile industry and leather industry generate considerable water pollution loads. The reported analytical data on KIA effluents [8] reveal very high concentration (mgl^{-1}) of Na(4650-9500), K(75-375), Ca(385-1082), Mg (120-389), SO_4 (1300-4286), HCO_3(329-2135), and Cl(8778-15632). The entire infrastructure relating to water supply and sewerage system of the area has been seriously damaged due to the rapid unplanned expansion of industries, absence of waste water treatment facilities, and lack of proper repair and maintenance of the available sewerage system. The total population of Korang/Landhi is more the 876, 872 out of which only 1/3 is sewered [9], hence Korangi sewage discharge is also contributing a heavy pollution load to the ground water. The higher concentrations of chloride and nitrate, the established indicators of sewage pollution, also indicate that the waters are contaminated to varying degrees by untreated discharges of municipal wastes.

The use of ground water has increased considerably due to the acute shortage of supply water and consequently the water-table which used

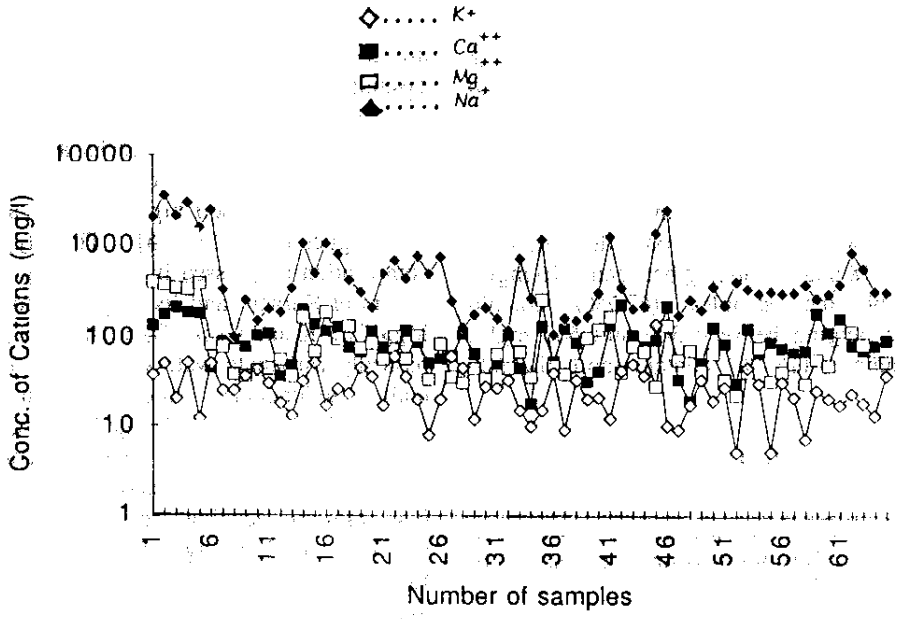

Fig. 3: Concentration of cations in ground water samples of Korangi/Landhi.

Table-3: Comparison of ground water quality of some major Pakistani cities (10) (values shown are means; ranges are shown in parentheses)

City/Town	pH	E.C. (μS/cm)	T.D.S. (mgl^{-1})	Total Hardness (mgl^{-1} $CaCO_3$)	Na^+ (mgl^{-1})	Cl^- (mgl^{-1})
Lahore	7.7	500	380	240	40	47
	(7.6-7.9)	(400-700)	(280-490)	(180-300)	(20-60)	(14-80)
Rawalpindi	8.0	700	450	260	48	33
	(7.8-8.1)	(400-900)	(286-636)	(200-330)	(32-66)	(22-44)
Multan	8.1	800	550	270	60	130
	(7.5-8.3)	(500-1000)	(350-700)	(170-370)	(30-90)	(40-220)
Faisalabad	8.4	700	510	132	77	39
	(8.2-8.6)	(400-1000)	(292-725)	(74-190)	(50-104)	(21-56)
Peshawar	7.8	400	290	120	17	50
	(7.5-7.9)	(390-450)	(260-300)	(100-150)	(11-26)	(21-64)
Mardan	7.4	430	320	170	18	30
	(7.2-7.6)	(360-500)	(230-360)	(140-190)	(15-23)	(26-54)
Quetta	7.9	1035	700	325	36	77
	(7.5-8.6)	(570-1500)	(400-1000)	(170-480)	(26-44)	(54-100)
Gwadar	7.1	84500	61726	1142	700	9864
	(7.0-7.1)	(29000-97400)	(20000-68180)	(684-1600)	(236-900)	(2884-18844)
Korangi/Landhi	7.5	4163	2653	628	630	841
	(6.5-8.4)	(1342-18064	(872-11730)	(193-2030)	(100-3499)	(126-5400)
WHO Guideline (1984)	6.6-8.5	-	1000	500	200	250

to be about 20-25 feet in 1960-80 has now fallen to the level of 40-60 feet. Since the area is located near the sea, the excessive extraction of water from many wells/handpumps of the area at a rate exceeding "Safe yield", has caused salt water encroachment. Thus most of the well/handpump waters have become enriched in ions characteristics of saline water.

Table-3 shows a comparison of ground water quality of some major cities of Pakistan [10] with that of the Korangi/Landhi. Except for the highly saline water of Gawadar, the water of all other cities is generally good and within the limits of WHO guidelines for drinking water. The ground water quality of Korangi/Landhi is poor and except for pH, the average levels of all the physico-

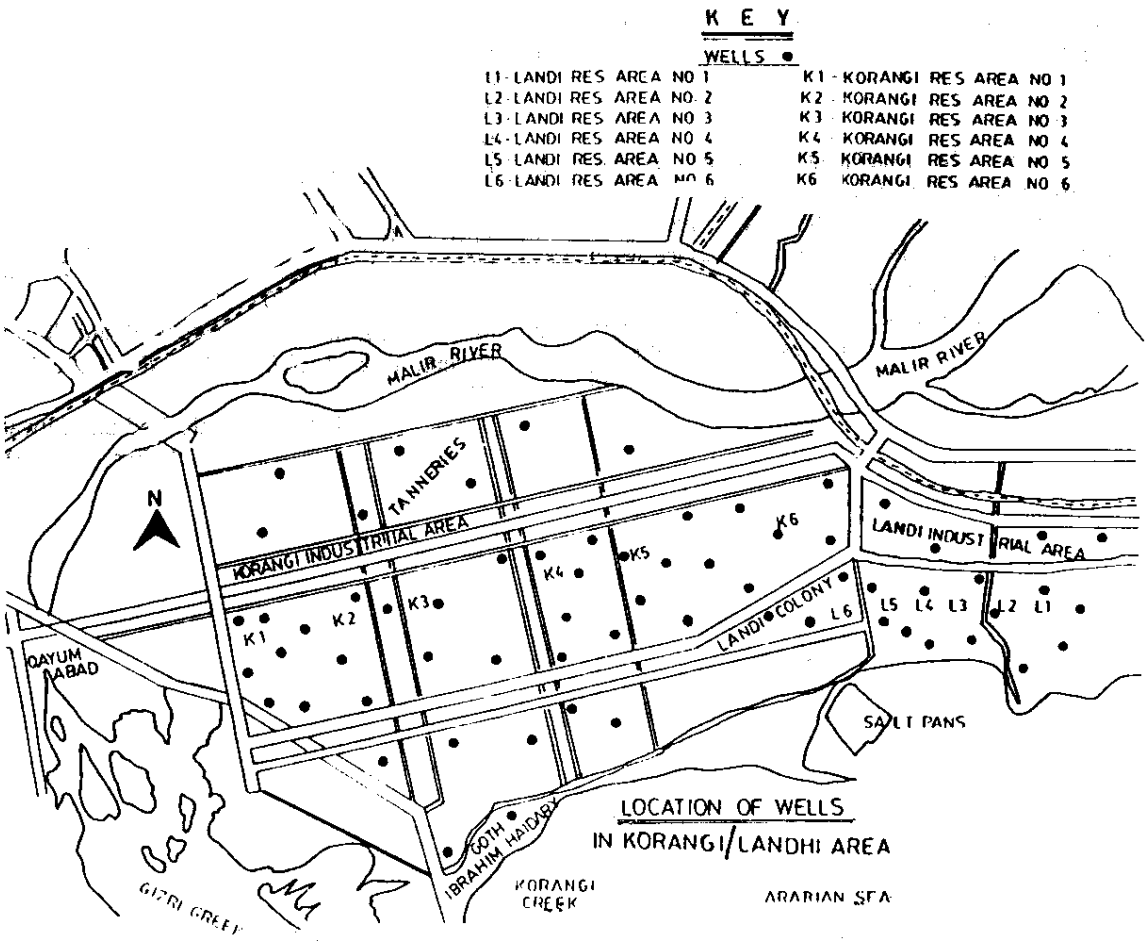

Fig. 4: Locationof wells in Korangi/Landhi.

chemical parameters are significantly higher than the recommended limits of WHO [11].

Experimental

A total of 65 samples were collected for the study by standard methods [12]. Except for a few well water samples, most of the samples were collected from handpumps/boreholes. Korangi/ Landhi is a large area comprising 12 residential sectors and 2 industrial areas viz. Korangi Industrial Area (KIA) and Landhi Industrial Area (LIA). The collection of samples was so arranged as to make the samples the most representative of the area. The sampling points have been shown in the location map of the area (Fig. 4).

Samples were collected in 2 lit. screw cap plastic containers, which were cleaned sequentially with detergent wash, tap water rinse, 24 hrs soak in 1% HNO_3 and several distilled water rinses, then dried at 100°C for 1 hr, cooled to room temperature, capped and labelled. Samples were immediately brought to the laboratory and refrigerated at 4°C.

Analytical grade (A.R) chemicals were used in the preparation of reagents and standards. Physical measurement and chemical analyses were carried out in triplicate for each sample and the average values were recorded. Standard spectrophotometric, flame photometric, gravimetric and titrimetric methods were employed for the analysis of the samples [12].

pH and conductivity were measured immediately after collection whereas all the other

estimations were completed within 2 days after sampling.

Conclusion

It may be concluded from the present investigation that the composition of ground water of Korangi/Landhi area has been deteriorated to a large extent due to the seepage from surface water constituting domestic and industrial waste water and sea water encroachment. Good quality well water is scarce in the area, mostly the waters are brackish containing undesirable amounts of chemical constituents which have rendered them unfit for human consumption as well as general industrial use. This study suggests the urgent need for the monitoring of ground water sources of Karachi city and their protection from contamination by domestic, municipal and industrial pollution.

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