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UNDERGROUND WATER CHARACTERISTICS OF MALIR RIVER CATCHMENT AREA

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ABSTRACT

This study evaluated the extent of physical, chemical and microbiological contamination in ground water of Malir River catchment area. Underground water samples were collected from 10 different locations of the catchment area including tributaries of Malir River during pre and postmoonsoon seasons, 2004. The samples were analysed for pH, total dissolved solids (TDS), total suspended solids (TSS), alkalinity, BOD_5, Chloride, COD, hardness, nitrate and phosphates along with the organisms of public health importance. The aveargе pH values ranged from neutral to alkaline (6.8-7.5), TDS 350-1322 and TSS 20-95 mg/l. The average concentration of chloride was not much as compared to WHO guide lines. The average concentration of BOD_5 (23.50-25.50 mg/l) and COD (529-532mg/l) represents the organic and inorganic contamination of ground water. The concentration of nitrate and phosphates was not much alarming however, their continuous accumulation poses serious health implications. This could possibly be due to indiscriminate use of inorganic fertilizers as well as the uncontrolled dumping of domestic wastewater generated by the rural communities. It is quiet alarming that none of the water sample was fit for human consumption from the public health point of view. The study reveals that a more intensive survey should be undertaken to determine the possible sources of contamination of ground water aquifers of Malir River catchment area so as to uplift the environmental health and to protect ground water reserves from contamination on a logical long-term basis.

Key words: Malir River, catchment area, pollution, and public health

INTRODUCTION

The word Malir denotes basically a region of pastoral wealth, a patch of rich and fertile plain or meadow in Sindhi. The district lies between 24˚45' to 25˚ 37' north latitudes and 67˚ 06' to 67˚ 34' east longitudes and is bounded on the north by Dadu district, on the south by Thatta district and Arabian sea and on the west by Karachi and Lasbela district of Balochistan province. The total area of the district is 2268 square kilometers. Malir district has a variegated topography, ranging in height from below the datum level in south along the tidal swamps and mud flats of Ibrahim Hyderi and Bin Qasim coastal strips to the maximum of 525 meters above the mean sea level at Mol escarpment in Sindh Kohistan. In the upper reaches the two main effluents of Malir are Khadeji Nadi and Mol Nadi, which have their catchments basins in Sindh Kohistan in a synclinal fold between the main Kirthar range and its off-shoot branches. Malir River, ephemeral in nature, flows in the district. This river is constituted from two major tributaries, Mol and Khadeji and smaller tributaries of Konkar, Thaddo and Sukkhan (Khan, 1979a, b).

Khadeji is perennial river in its upper reaches. The water of Khadeji Falls percolates into the sedimentary rocks after going some distance and it replenishes within Malir basin in the southern down stream. Some amount of water flows throughout the year inside the downward basin of Khadeji River. The southern stretch of Malir district follows the coastal strip of Korangi and Gharo creeks, demarcating the northern side of the old Indus delta. The topography of Malir river can be divided in two parts: (1) upper portion, it is hilly undulating and without any vegetation (2) lower portion: This consists of a 30 miles strip from confluence of Mol and Khadeji to sea and occupies about 32,000 acres. The ground level ranges from 0.0 foot to 350 feet above the mean sea level and thus land is nearly level to level plain (ACE-1993). The Malir River has a wide bed with a narrow strip of flood plains along its banks. Most of the soils are fine to coarse sand and occasionally mixed with gravels and boulders. However, silty sand and silt beds are also found in patches. Apart from Mol and Khadeji the other tributaries of Malir River are Thaddo, Sukkan, Turi, and Jarendo nallas. Malir River travels a distance of 18 km approximately within the city limits. It can be seen that large scale unauthorized agricultural activities are being taking place in the Malir River bed which is responsible for altering the route of flowing water. In addition cattle dens are also present in the riverbed. It was alarming to observe the practice of solid waste dumping and burning in the riverbed, thus producing harmful gases in the atmosphere.

The present study was aimed at the collection and analysis of water samples from the Malir River catchment area so as to determine the extent of pollution load which is responsible for serious environmental health implications.

MATERIALS AND METHODS

Samples were collected from 10 different sampling sites along the Malir River catchment area as indicated in Fig.1. The description of these sites and the associated activities along with the coordinates of Malir River are outlined in Table 1. The present study was conducted from February and September 2004 to observe the pre and post monsoon effect on ground water quality.

Physical Parameters

The physical parameters of water samples tested were (i) pH (ii) total dissolved solids (TDS) and (iii) total suspended solids (TSS). The pH of the samples was determined by using Orion pH meter. While the other two parameters were measured by the methods described in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

Biochemical and Chemical Parameters

These parameters include (i) Alkalinity (ii) BOD_5 (Bio-chemical oxygen demand) (iii) COD (Chemical oxygen demand) (iv) Chloride (v) Hardness (vi) Nitrate (vii) and (viii) Phosphates. The above mentioned parameters were determined by titration, Azide modification, Dichromate reflux, silver nitrate, EDTA, Brucine sulphanilic acid Ascorbic acid methods respectively as mentioned in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

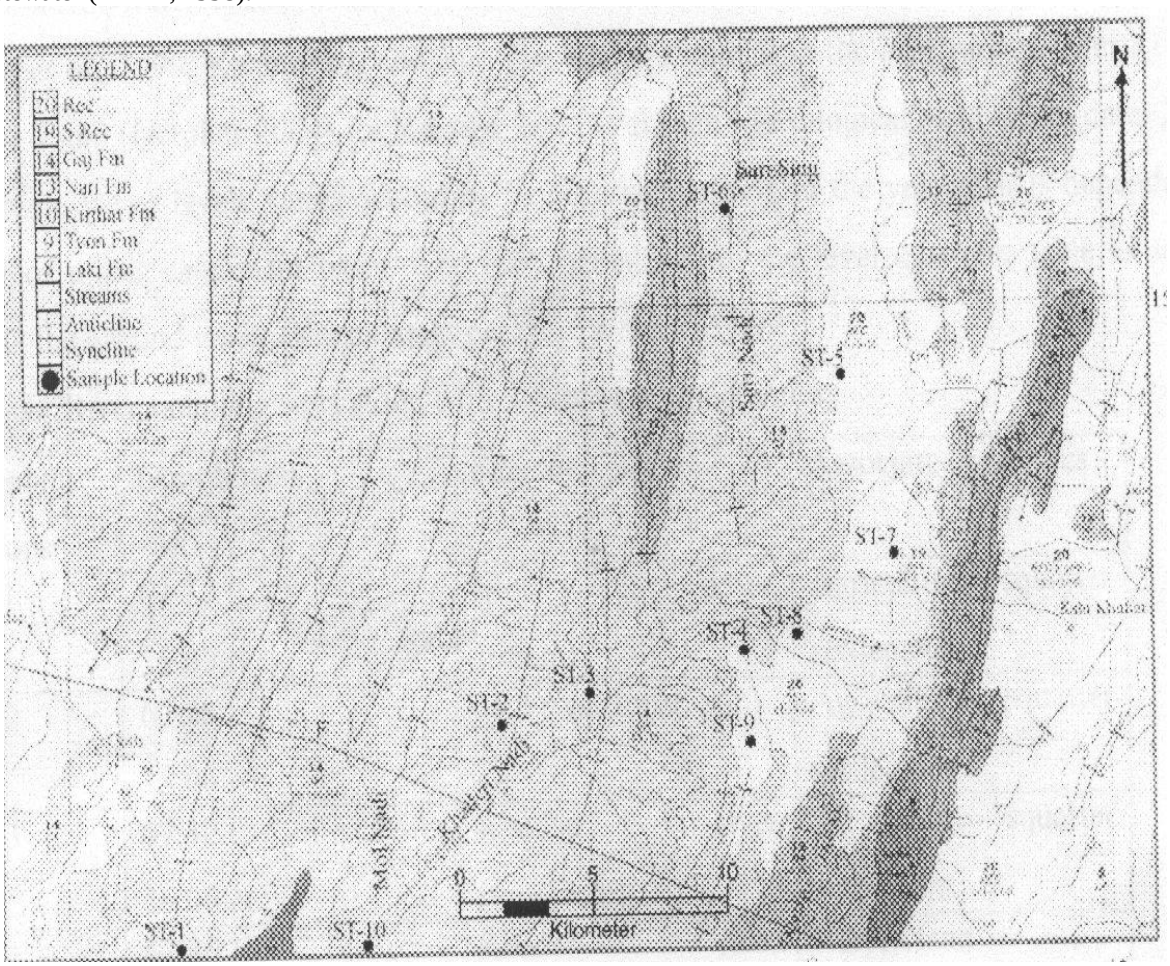

Fig. 1. Malir River catchment area sampling sites.

Microbiological parameters

The microbiological quality of water samples was determined by MPN (Most Probable Number Technique) as outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

Table 1. Malir River sampling sites along with the associated activities.

S. No.	Sampling stations	Coordinates	Sampling sites	Associated activities
1.	ST-1	67.17 E 25.00 N	Mol river (down stream)	Agriculture, squatter settlement
2.	ST-2	67.28 E 25.04 N	Mol river (upstream)	Agriculture squatter settlement
3.	ST-3	67.30 E 25.06 N	Khadeji river (upstream)	Agriculture squatter settlement
4.	ST-4	67.35 E 25.07 N	Khadeji river (upstream)	Barren land
5.	ST-5	67.38 E 25.12 N	Tributary of Sari Nadi (up stream)	Agriculture, squatter settlement
6.	ST-6	67.34 E 25.17 N	Sari Sing	Barren land
7.	ST-7	67.39 E 25.09 N	Tributary of Sari Nadi (Middle)	Barren land
8.	ST-8	67.35 E 25.06 N	Tributary of Sari Nadi (Middle)	Barren land
9.	ST-9	67.34 E 25.04 N	Tributary of Sari Nadi (down stream)	Agriculture, squatter settlement
10.	ST-10	67.23 E 25.01 N	Junction of Mol and Khadeji river	Agriculture, squatter settlement

RESULTS AND DISCUSSION

River flow, bed slope and subsurface conditions and rain fall

The upper portion of Malir River is undulating whereas lower portion comprises of land, which is nearly level plain. The area is covered with fine to coarse sand whereas, silty sand and silt beds are also found. Mostly the catchment area of the river is occupied with unauthorized agricultural activities, which altered the flow of water. Since Karachi gets very scarce rain therefore, Malir River remains dry during most of the time of year. The river gets rainwater from its catchment area and recharges the aquifers. During dry season and in the absence of rain the river acts as an open sewer receiving, domestic, industrial and trade wastewater through different tributaries, overflowing gutters and storm water drains transformed into and acts as open sewerage network (Khan *et al*. 1999; Khan *et al.,* 1999; Khan and Khan, 2001). The average rainfall in the area ranges from 3.0 (July 2004) to 34.5 mm (October 2004) for the year 2004 (Anonymous, 2004). The subsurface water levels varies according to different periods of the year as it is dependent on the rainfall of upper catchment basin. The high rainfalls raise the level of water table as well as contaminate the ground water (Kazmi and Ghori, 1994).

Physical Parameters

The results of the physical parameters are reported in Table 2. The average pH of Malir River fluctuated between 7.2 to 7.18 indicating that the underground water river is neither too acidic nor basic (Table 3). In general, the distribution of SS solids is not uniform throughout the aquifer (Defrain and Schmidt, 1992) as can be seen in the present case, as approximately 75 % of the municipal suspended solids are organic in nature of which nearly half are settlebale. Therefore, The variations in the amount of TDS and TSS at various stations are given in Table 2. The values of TDS ranged from 408-1322 and 350-1245 in pre and post monsoon seasons respectively. The concentration of TDS increases successively and reaches to its maximum at ST-7 and ST-8 which represents the tributary of Sari Nadi where no agricultural activity was seen. This would mean that TDC gets concentrated at these particular sites. The average TSS values during pre and post monsoon seasons fluctuated between 52.60-64.20 mg/l.

These values are indicator of organic pollution in under ground water. It was observed during the field survey that no sewerage system exists for the rural communities living in the area. The wastewater which produces during domestic activities disposed off directly on to the open land which is responsible for organic pollution of underground water. This also indicates that solid in underground water were mostly in the soluble form rather than in the suspended form (Khan *et al*., 1999; Khan and Khan., 2001).

Table 2. Physical characteristics of underground water from Malir River catchment area.

Sampling site	pH		Total dissolved solids (mg/l)		Total suspended solids (mg/l)	
	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004
ST-1	7.1	7.1	808	780	54	60
ST-2	7.5	7.3	440	410	75	35
ST-3	7.3	7.4	408	375	65	40
ST-4	6.8	6.8	449	350	20	80
ST-5	7.4	7.2	565	460	50	20
ST-6	7.4	7.3	557	500	72	35
ST-7	7.3	7.4	1322	1002	70	95
ST-8	6.9	7.0	1314	1245	86	74
ST-9	7.2	7.0	416	400	65	25
ST-10	7.1	7.3	540	545	85	62
Average	7.2	7.18	682	607	64.20	52.60
Min-Max	6.8-7.5	6.8-7.4	408-1322	350-1245	20-86	25-95

Biochemical and Chemical Parameters

The values of alkalinity were consistent through out the study period at each sampling site (Table 3). It was observed that carbonate alkalinity was absent thought out the study period. The alkalinity thus represents only bicarbonate alkalinity witch ranged between 240-380 mg/l and 245-350 mg/l respectively during pre and post monsoon period.

BOD_5 represents the concentration of biologically oxidizable matter and that can be taken into account as indicator of organic pollution. The average BOD_5 values for pre and post monsoon seasons were 23.5 and 25.5mg/l respectively (Table 3). The minimum BOD_5 value (10 mg/l) was observed at ST-2, 9 and 10 whereas, maximum was observed at ST 4 and 5 (50mg/l). ST-5 was the site where maximum agricultural activity was observed. In addition, squatter settlement of rural communities were also present. Ideally the drinking water should have zero BOD_5 level, however, these values represents organic contamination of underground water.

The average chloride concentration fluctuates only with a narrow range of 261-275 mg/l respectively for per and post monsoon seasons (Table 3). Only at ST-7 the value was quite high (665 and 795 mg/l) which deteriorate the palatability of water. This is the area that comprises of barren land where no agricultural activity was observed (Table 2).

COD is a measure of chemically oxidizable substances present in water. It includes both biologically and chemically utilizable substances. The minimum and maximum values for COD were 160-1560 mg/l and 180-1430 mg/l (Table 3) respectively for pre and post monsoon seasons. The higher COD values represents that in addition to biologically oxidisable material of domestic original chemical oxidizable substances were also present in the ground water aquifer of the catchment area. Pesticides could be one of the significant sources of increased COD values as the catchment area mostly comprises of agricultural land. The continuous accumulation of pesticides is a serious threat to environmental health.

The hardness values depicted that the water quality ranged from low, medium and hard water and the average values were 346 and 310 mg/L for pre and post monsoon seasons respectively. As such there is no significant health effected reported for hard water (WHO, 1996). However studies have shown correlation between hard water and cardiovascular diseases, although the data is scanty in this respect (WHO, 1996).

Nitrate and phosphates are considered as nutrient parameters and are important for biological activity such as for the algal growth etc. High concentration of nitrates and phosphates when discharged into lakes and stream results in algal bloom, which depreciates the quality of water if used for human consumption and other wise. Algal blooms in any water body impart bad tastes, odour and colour, which are difficult to remove. Nitrates in addition, are also responsible for blue baby syndrome, which is responsible for infant mortality (WHO, 1996). The concentration of

nitrate is to low as compared to phosphate (Table 3). The possible sources of nitrate and phosphates could be the inorganic fertilizers, which are being used using indiscriminately by the farmers of nearby agricultural field contaminating the ground water aquifers. However, the concentrations of are not much alarming but their continuous accumulation may be toxic from environmental health view point in future.

Table 3. Biochemical and chemical characteristics of underground water of Malir River catchment area.

Sampling sites	Parameters mg/l									
	Alkalinity as $CaCO_3$		BOD_5		Chloride		COD		Hardness as $CaCO_3$	
	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004
ST-1	300	310	10	30	340	335	920	850	270	270
ST-2	260	250	20	10	170	190	280	275	380	365
ST-3	260	245	25	30	110	100	160	180	100	120
ST-4	310	310	50	20	110	125	240	265	330	240
ST-5	380	350	20	50	195	200	240	235	80	100
ST-6	240	250	45	20	105	125	235	230	180	173
ST-7	290	270	20	30	795	655	1560	1430	730	645
ST-8	350	310	25	25	730	676	1250	1370	830	743
ST-9	350	330	10	15	90	85	220	215	270	250
ST-10	340	310	10	25	110	120	215	245	290	200
Average	308	293	23.50	25.50	275	261	532	529	346	310
Min-Max	240-380	245-350	10-50	10-50	90-795	85-676	160-1560	180-1430	80-830	120-743

Bacteriological Parameters

Bacteriological parameters are often reported in terms of total coliforms and faecal coliforms, which are indicators of faecal contamination. The results of bacteriological quality of underground water are presented in Table 5. It can be seen from the Table 5 that none of the sample is fit for human consumption. The source of these indicator organisms could possibly be the domestic wastewater discharge, which is responsible serious health implications. The problems is confirmed by conversing the people who reported that the diarhoeal diseases are most commonly prevalent in the communities, which is responsible for infant mortality..

Table 4. Nutrient concentrations of underground water of Malir River catchment area.

Sampling sites	Parameters mg/l			
	Nitrate		Phosphates	
	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004
ST-1	0.065	0.045	4.13	2.17
ST-2	0.042	0.042	2.88	1.65
ST-3	0.170	0.067	2.82	0.87
ST-4	0.093	0.082	2.17	1.20
ST-5	0.085	0.065	0.85	1.43
ST-6	0.061	0.065	5.41	3.42
ST-7	0.175	0.05	3.86	2.10
ST-8	0.165	0.09	4.36	3.31
ST-9	0.085	0.08	4.51	2.21
ST-10	0.096	0.075	5.13	4.23
Average	0.1037	0.066	3.612	2.259
Min-Max	0.042-0.175	0.042-0.092	0.85-5.41	0.87-4.23

Table 5. Bacteriological characteristics of underground water of Malir River catchment area.

Sampling sites	Most Probable Number (MPN)/ 100 ml						Remarks
	Total coliform count		Total faecal coliforms		Total faecal streptococci		
	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	Feb. 2004	Sept. 2004	
M-1	>2400	120	1100	23	<3	<3	UFHC
M-2	>2400	93	39	9	<3	<3	UFHC
M-3	1100	150	21	<3	<3	<3	UFHC
M-4	1100	150	150	28	<3	<3	UFHC
M-5	1100	23	21	<3	<3	<3	UFHC
M-6	210	93	39	9	<3	<3	UFHC
M-7	39	9	7	4	<3	<3	UFHC
M-8	150	28	23	4	<3	<3	UFHC
M-9	23	4	21	4	<3	<3	UFHC
M-10	460	15	9	9	<3	<3	UFHC

UFHC= Unfit for human consumption; WHO guidelines for drinking water (1996) = <3 coliforms/ 100 ml

CONCLUSION

It is concluded the aquifers of Malir River catchment area are grossly polluted with organic pollution. Indiscriminate use of inorganic fertilizers further aggravated the problem. The study has shown the need for extensive monitoring of contamination level in underground water of Malir river catchment area. It is also recommended Government should take initiative to control pollution and to prevent water resources of Malir River catchment area which are depleting rapidly.

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