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QUALITY OF DRINKING WATER IN HUB RIVER CATCHMENT AREA, SINDH PAKISTAN

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ABSTRACT

This cross sectional study investigates the drinking water quality of Hub river catchment area. The quality of water was examined through bacteriological, chemical and heavy metal analysis. Water from all the samples failed to meet standards for the bacteriological parameters of drinking water, however chemical quality was acceptable. The presence of "lead" indicates the heavy metal contamination which could be potentially dangerous from the public health point of view. This would mean that this important water resource is grossly polluted and could be a potential threat to the people who consume water from the storage.

Key words: Hub dam, Bacteriological quality, chemical quality

INTRODUCTION

Sindh is the southeastern province of Pakistan, bounded on the east by the Indian border of Rajasthan, in the south by the Ran of Kutch and the Arabian Sea, in the west by the arid rocky mountains of Balochistan and in the North by irrigated plains of Punjab. About 88,000 sq. km. area of Sindh is regarded as arid zone, which is nearly 60% of total geographical area of Sindh province. Administratively, Sindh Arid Zone Development Authority has divided the arid areas of Sindh province into three zones; a) Kohistan (the western side of the Indus Valley) b) Thar (the eastern area of Sindh Province). Thar is further subdivided into Nara region in the North and Thar region in the south c) Southern region (Rajput, *et al.,* 1991). Thar region is characterized with extreme temperature, severe drought accompanied by high wind velocity and too scanty rainfall (Ali, 1985; Malik, 1985).

Hub Dam extends over an area of about 27,219 ha between 25˚ 15' N and 67˚ 07' E with an elevation of 150 meters. Hub Dam was constructed in 1981 on Hub River, in a region of arid plains and low stony hills of Kirthar Range. Much of the shoreline is steeply shelving and stony, but there are many shallow bays and small islands within this natural reservoir. The larger part of the reservoir (in Balochistan) is unprotected; the eastern shore and southern area of the Dam (in Sindh) however, are protected in the Kirthar National Park and Hub Dam Wildlife Sanctuary respectively. Forest plantation and recreational park of about 80 hectare has been established by the Balochistan Forestry and Wildlife Department on a peninsula in the reservoir. Part of the area has been planted with trees (mainly Eucalyptus) and some recreational facilities also have been provided.

Since the construction of Hub dam in the early 1980's the reservoir has rapidly become an important staging and wintering area for migratory of waterfowl, including at least one threatened specie (*Pelecanus crispus*). Mid winter waterfowl counts are continuously decreasing in the last few years due to severe drought in the area and excessive pollution load in the reservoir. The site clearly qualifies as a wetland of international importance under Ramsar Criteria 2a and 3a. The area is important for breeding waterfowl, e.g. *Gelochelidon nilotic*, but commercial fishing activities in the lake cause major disturbances to waterfowl populations (Scot, *et al.*, 1990).

Karachi is located about 70 kilometers away from the Hub dam. The dam supplies about 20-25% water to the city of Karachi (MacDonald and Partners, 1985: United Nations 1988; Karachi Water and Sewerage Board, 1994). Karachi Water and Sewerage Board (KW&SB) operates water treatment plants near the dam and claims to supply water that is free from bacterial contaminants (Bakhtiar, 1992). The treatment plants operate on "flocculation – sand filtration – chlorination" principle. The water quality reported by the authorities meets the WHO standards whereas, the water quality tested by NGO's, media and other agencies like the Institute of Environmental Studies and Department of Microbiology, University of Karachi do not support the KW&SB claims. The discrepancy may be for several reasons. It could be due to the fact that collection of water samples by the authorities is from source i.e. the treatment plants, while non-conforming results are from samples collected from consumer's taps. The sampling techniques and methods of analysis also differ. Water in the distribution pipelines may also get contaminated during flow. The sewerage and fresh water lines in Karachi have been laid crisscrossed and both leak profusely in most areas that could be the major source of contamination.

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The bitter fact is that even after having the supply of 100 million gallons from Hub, the shortfall of 100 million gallons is still there. KW&SB claims that, total supply to the city at present is approximately about 455 million gallons which is normally at 555 million gallons daily with 100 million gallons from Hub. Infact, the total demand is about 650 MGD.

Since the Hub dam is an important water source for Karachi hence it needs special attention. It is with this aim the present research investigation was conducted to determine the extent of bacteriological and chemical contamination to asses the public health profile of the Hub dam water reservoir.

MATERIALS AND METHODS

During the study 20 samples were taken from the Hub Dam catchment area in the month of September, 2005 (Before and after rain).

All samples were grab samples taken at different time and places. Standard methods were followed in collecting, handling and analyzing samples. Date and coordinates (through GPS) of places were noted in order to demonstrate and to plot exact map. The samples were analyzed as per standard methods for the examination of water and waste water (APHA, 1992).

RESULTS AND DISCUSSION

The sites for the sample collection are presented in Fig1.Results of bacteriological analysis of water samples from the reservoir are presented in Table 1. It can be seen that all water samples were contaminated with the organisms of public health importance. Meybeck, (1985) reported that the faecal coliforms up to 10^6/100ml are commonly found in Pakistan, India and Indonesia. These organisms are the major source of ailments in the local population. Gumbo (1985) reported that infectious water related diseases are most frequent in the developing countries. Gumbo (1985) also reported that unless drinking water supplies are improved there is little hope of controlling communicable diseases in the population in the developing countries (Table 1).

The samples were collected in two phases, sample 1 to 7 collected before precipitation and the rest after precipitation for bacteriological, chemical and heavy metal analysis.

Bacteriological analysis reveals that there is an increase in contamination of organisms of public health importance after rain. This could possibly be due to the runoff from the surroundings providing favorable conditions for the organisms to sustain and multiply. Samples 1 to 7 are contaminated only with TCC whereas, sample 8 to 20 contain faecal contamination beyond WHO standards.

Since the number of faecal coliforms and faecal streptococci discharged by human beings and animals are significantly different, hence the ratio of faecal coliforms (FC) to faecal streptococci (FS) count in a given sample can be used to detect whether the suspect is derived from human or from animal wastes. The FC/FS ratio in water in animal origin is generally considered to be less than 1.0 whereas it is more than 4.0 for human beings. If the ratio is within 1 to 2 the interpretation is uncertain. This ratio is very helpful in determining the source of pollution (Metcalf and Eddy, 1991). Total faecal streptococci were absent in all the samples except sample number 8 and 18 which were from the most polluted sites, having the FC/FS ratio of 1 and 5.75 respectively. The reason of faecal contamination could be the anthropogenic activities near the reservoir.

According to WHO (1993) guidelines for TDS is 1000 mg/l, Chloride 250 mg Cl^-/l, Hardness 500 mg/l, Nitrate 50mg/l and Sulfate 250mg/l.

On comparison, pH and TDS (except sample number 14 and 19) were found to be satisfactory whereas other parameters are showing some deviation from reference value. All samples contain high number of suspended solids which indicates excessive load of organic matter. We can see from analysis there is increase in suspended solids and number of bacteria per liter especially after precipitation. This organic matter is great source of nutrient for the bacteria to sustain and multiply. TDS describe the load of inorganic matter and directly relates to conductivity of the water, TDS of all the samples were found within limit (except sample number 14 and 19) and there was no much significant change in the quantity (TDS) before and after precipitation.

Chloride and hardness of the samples were fluctuating within a range of 50-475 mg/l and 240-800 mg/l respectively. Chloride content of sample does not impose any significant health impact except taste. Beyond 500 mg/l (Hardness) is not fit for drinking purpose and for domestic usage. All samples contain sulfate within desired concentration. The concentration of phosphate fluctuates within a narrow range of 40.09-0.236 mg/l, which should not be present in drinking water. Presence of phosphate indicates the dilution of agricultural runoff.

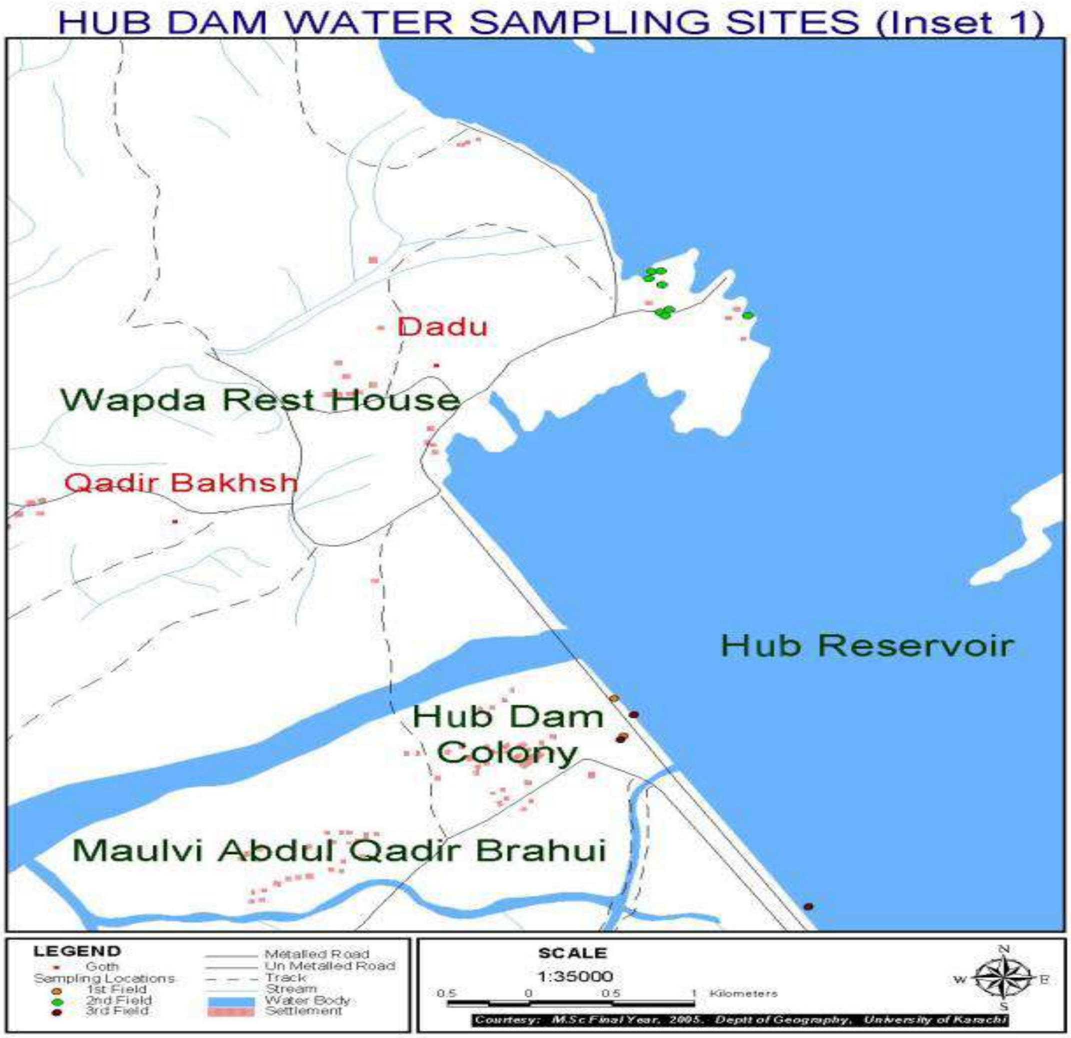

Fig1. Site of sample collection of Hub dam catchment area.

In small quantities, certain heavy metals are nutritionally essential for health. Some of these are referred to as the trace elements (e.g., iron, copper, manganese, and zinc) but presence of heavy metals have potential to produce serious health hazards, heavy metals become toxic as they are not metabolised by the body and accumulate in the soft tissues.

According to WHO (1993) standards for lead is 0 mg/l, Nickel 0.02 mg/l, Copper 1.0 mg/l, Manganese 0.05 mg/l and Iron is 0.3 mg/l.

Lead was found present in all the samples and its concentration remains same before and after precipitation. Nickel is absent in all samples before precipitation (except sample 4) but present in all sample after precipitation. The rest of the metals concentration was within the permissible limit as per WHO guide lines except Manganese (Mn) and Iron (Fe). Concentration of copper was satisfactory throughout the study. Manganese was in higher concentration and its concentration increased especially after precipitation. Due to dilution of runoff especially after precipitation iron (Fe) was showing higher value.

In the second phase of the study, chemical analyses were conducted that shows significant increase almost in every parameter.

The study reveals that quality of raw water is not good for consumption without proper and advance treatment. Proper selection and protection of water sources as in present case is of prime importance in the provision of safe drinking water. It is always better to protect water from contamination than to treat it after it has been contaminated. Protection of surface water is however, a problem, if water supplies are to remain potable, both the source and the catchments need protection. For this purpose, the dam shed should be protected from contamination due to anthropogenic activities.

Table.1 Result of bacteriological analysis of water samples from Hub dam catchment area

S.No.	Date of Sample Collection	Coordinates		Parameters MPN/100ml			WHO Guidelines	Remarks
		East	North	TCC	TFC	TFS		
1	3-9-2005	309946	2793241	900	-	-	<3	UFHC
2	3-9-2005	318502	2798800	400	-	-	<3	UFHC
3	3-9-2005	316635	2797833	2300	-	-	<3	UFHC
4	3-9-2005	316637	2797835	900	-	-	<3	UFHC
5	3-9-2005	311303	2791482	24000	-	-	<3	UFHC
6	3-9-2005	309999	2792903	900	-	-	<3	UFHC
7	3-9-2005	303524	2788241	1500	-	-	<3	UFHC
8	14-9-2005	310160	2796776	430	4	4	<3	UFHC
9	14-9-2005	310220	2796706	4300	9	-	<3	UFHC
10	14-9-2005	310271	2796732	1500	<3	-	<3	UFHC
11	14-9-2005	310249	2796674	2300	21	-	<3	UFHC
12	14-9-2005	310748	2796675	150	240	-	<3	UFHC
13	14-9-2005	310284	2796698	700	150	-	<3	UFHC
14	14-9-2005	310263	2796725	-	-	-	<3	UFHC
15	14-9-2005	310231	2796954	28	28	-	<3	UFHC
16	14-9-2005	310190	2796996	400	<3	-	<3	UFHC
17	14-9-2005	310147	2797007	900	23	-	<3	UFHC
18	14-9-2005	310168	2797068	4000	23	4	<3	UFHC
19	14-9-2005	310189	2797088	2200	19	-	<3	UFHC
20	14-9-2005	310219	2797111	1900	25	-	<3	UFHC

TCC = Total Coliforms. TFS = Total Faecal Streptococci.
TFC = Total Faecal Coliforms, UFHC = Unfit For Human Consumption

Conclusion

The study reveals that the water quality in Hub Dam does not meet the WHO guide lines (1993). From the point of view of quality and quantity the Hub water reservoir's critical problems arise from the following factors.

i. There is negligible rainfall through out the year and therefore no effective recharge.
ii. Water is grossly polluted with the organism of public health importance.
iii. Hub dam is facing excessive pollution load of both, bacteriological and chemical contaminants.
iv. Presence of contaminants like phenol and cyanide increases the chlorine demand for disinfection.
v. Presence of certain heavy metals indicates contamination of local industrial waste.

vii. No protection measures have been adopted to protect the reservoir from contamination from external sources.

The study envisaged that quality of water is not fit for human consumption. However, this conclusion is based on the very limited number of samples therefore it is suggested to carry out more extensive study to identify the sources of pollution and to suggest mitigation measures.

Table.2 Results of chemical analysis of water samples from Hub dam catchments area

S. No.	DATE OF SAMPLE COLLECTION	COORDINATES UTM E	N	pH	TDS mg/l	Cl^- mg/l	H'NESS mg/l	NO3 mg/l	PO4 mg/l	SO4 mg/l
S-1	03-09-2005	309946	2793241	7.57	812	475	700	0.3981	0.236	193
S-2	03-09-2005	318502	2798800	6.97	836	350	650	0.909	0.25	118.4
S-3	03-09-2005	316635	2797833	7.37	870	275	650	0.3987	0.091	132.1
S-4	03-09-2005	316637	2797835	7.07	796	250	600	0.2728	BDL	187
S-5	03-09-2005	311303	2791482	7.07	868	375	550	0.449	BDL	157
S-6	03-09-2005	309999	2792903	7.67	800	425	500	0.4017	BDL	107.2
S-7	03-09-2005	303524	2788241	7.67	760	475	450	0.3101	BDL	104.1
S-8	14-09-2005	310160	2796776	7.97	656	250	600	0.444	1.112	150.3
S-9	14-09-2005	310220	2796706	7.87	848	94	240	0.5819	0.10	103.1
S-10	14-09-2005	310271	2796732	7.47	628	50	500	0.5759	0.203	99
S-11	14-09-2005	310249	2796674	7.67	610	90	240	0.6222	0.136	92
S-12	14-09-2005	310748	2796675	7.87	268	100	500	0.661	0.145	78.01
S-13	14-09-2005	310284	2796698	7.77	320	92	244	0.662	0.124	102
S-14	14-09-2005	310263	2796725	7.87	1052	100	400	0.5849	0.153	73
S-15	14-09-2005	310231	2796954	7.77	536	200	800	0.5346	0.118	66
S-16	14-09-2005	310190	2796996	7.87	872	150	400	0.4027	0.109	64
S-17	14-09-2005	310147	2797007	7.67	464	150	600	0.5346	0.202	74.3
S-18	14-09-2005	310168	2797078	7.77	525	100	800	0.5406	0.236	43.26
S-19	14-09-2005	310224	2797078	7.87	7300	100	400	0.6202	0.186	55.54
S-20	14-09-2005	310219	2797111	7.5	632	98	450	0.5048	0.192	67.7

BDL = Below Detectable Limit.

Table.3 Results of heavy metal analysis samples from Hub dam catchments area.

S. No.	DATE OF SAMPLE COLLECTION	COORDINATES UTM E	N	Pb mg/l	Ni mg/l	Cu mg/l	K mg/l	Mn mg/l	Fe mg/l
S-1	03-09-2005	309946	2793241	1.525	BDL	0.115	2.697	0.54	0.16
S-2	03-09-2005	318502	2798800	2.4	BDL	BDL	1.027	BDL	BDL
S-3	03-09-2005	316635	2797833	2.01	BDL	BDL	6.045	BDL	BDL
S-4	03-09-2005	316637	2797835	2.5	1.061	BDL	2.79	BDL	BDL
S-5	03-09-2005	311303	2791482	2.3	BDL	0.535	2.7	2.301	BDL
S-6	03-09-2005	309999	2792903	1.42	BDL	BDL	2.707	0.475	0.61
S-7	03-09-2005	303524	2788241	1.391	BDL	BDL	2.178	BDL	0.123
S-8	14-09-2005	310160	2796776	1.783	1.056	0.504	2.92	3.050	0.116
S-9	14-09-2005	310220	2796706	2.14	1.355	0.582	2.62	4.169	0.54
S-10	14-09-2005	310271	2796732	1.866	1.233	0.240	2.517	2.161	0.581
S-11	14-09-2005	310249	2796674	1.829	1.466	0.680	3.475	3.972	0.381
S-12	14-09-2005	310748	2796675	1.907	1.263	0.221	4.009	2.218	0.83
S-13	14-09-2005	310284	2796698	1.747	1.808	0.581	3.182	3.366	0.529
S-14	14-09-2005	310263	2796725	1.744	1.293	0.611	3.177	3.384	0.637
S-15	14-09-2005	310231	2796954	2.032	0.563	0.206	2.922	0.766	0.193
S-16	14-09-2005	310190	2796996	2.519	1.435	0.802	2.797	4.761	0.709
S-17	14-09-2005	310147	2797007	1.967	1.411	0.493	4.122	2.982	0.406
S-18	14-09-2005	310168	2797078	1.546	0.919	0.212	2.837	3.1	0.403
S-19	14-09-2005	310224	2797078	2.231	1.817	0.812	3.855	2.907	0.687
S-20	14-09-2005	310219	2797111	1.378	1.089	0.685	2.9	3.09	0.787

BDL = Below Detectable Limit

REFERENCES

Anonymoius (2000). Base Line Environmental Study of Kirthar National Park conducted by University of Melbourne in collaboration with PKP Exploration Ltd.

American Public Health Association (APHA 1998). *Standard Methods for the Examination of Water and Wastewater*. 19th edition. American Public Health Association. Washington DC.

Ali, S.I. (1991). Under exploited economic plants of Pakistan. *J. Arid. Environ*., 11:17-35.

Bakhtiar, I. (1992). The Hidden Menace. *The Herald, Karachi*. Vol 23. No.4: 27-33.

Gumbo, F.J. (1985). Water quality monitoring in Tanzania. *Water quality bulletin. Environment Canada*. 10: 174-180.

Lloyd, B.J., D.C. Wheeler and M. Pardon (1989). The relation Ship between water related disease and water quality with particular reference to urban water supply in developing country. *Wat. Sci. Tech*., 21. Book-2: 519-591.

Malik, A. R. (1985). Arid Zone Research II, Pattern exhibited by some desert species from district Khairpur, Sindh, Pakistan. *Sindh Uni. Res. J*. (Sci. Ser) 17: 73-85.

Karachi Water and Sewerage Board (1994). *Basic Facts*: 1993-1994, Karachi Water and Sewerage Board, Karachi.

MacDonald and Partners (1985). Feasibility study of future expansion of Karachi water supply system, MacDonald and Partners and Associated Consulting Engineers (ACE) ltd. Karachi.

Metcalf and Eddy, Inc. (1991). 3rd edition. Revised by Tchobanoglous. G. Wastewater Engineering Treatment Disposal and Reuse, McGraw-Hill Book Company, N.Y.

Meyberk, M. (1985). The GEMS/Water Programme (1978-1983). *Water quality bulletin Environment Canada,* 10: 167-173.

Rajput, M.T., B. Ahmed, S. S. Tahir and N.M. Bhatti (1991). A study of medicinal plants of Thar desert. *Sindh Uni. Res. J*., (Sci.Ser) 23: 73-85.

Rashid (1983). *Report on ground water potential in Kirthar National Park*. Pakistan Water and Power Development Authority, Hyderabad.

Scott, D. A. Rao, A. L. and Beg, A.R. (1990). The wetlands of Pakistan and the Ramsar Convention. Ramsar Advisory Mission to Pakistan.

United Nations (1988). *Population growth and policies in mega cities: Karachi.Department of International Economic and Social Affairs*. Population Policy Paper No.13, United Nations, New York.

WHO (1996). *Drinking water Quality Guide Lines*. WHO. Geneva.

www.epa.gov.safewater.mcl.html.inorganic.htm

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