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PUBLIC HEALTH STATUS OF THE GROUND WATER RESOURCES IN KHIRTHAR NATIONAL PARK, SINDH PAKISTAN

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ABSTRACT

This study investigates the public health profile of drinking water resources at Khirthar National Park (KNP). Groundwater discharged from springs or water pumped from wells provides the only source of water to sustain wild and domestic animals, irrigation and human use in KNP. The quality of water was examined by Most Probable Number Technique (MPN) using standard methods. The discharge of water from springs that were inspected was estimated to range from zero to 10 MLd^{-1}. Water from all but one of 20 wells and all from 14 springs that were sampled failed to meet WHO guidelines for the bacteriological quality of drinking water. Water conforming the guidelines came from one well only that was around 80 m deep.

Key-words: Drinking water profile, Khirthar National Park (KNP), ground water

INTRODUCTION

Khirthar National Park (KNP) is situated in the Sindh province of Pakistan to the north of the city of Karachi and to the west of Indus River. KNP extends over an area of about 3087 km^2 between latitudes 25^0 10' and 26^0 05' N and longitudes 67^0 10' and 67^0 55' E. It also includes the 3000 feet high Khirthar Range of mountains and an area consisting mostly of dry, arid landscapes with sparse hardy vegetation and out crops.

Khirthar is the oldest and the largest of Pakistan's four parks to be included in the World Conservation Union (IUCN) National Parks list and is an area protected under existing legislations. In addition, the park is also surrounded by a complex of protected areas, which include Hub dam and Mahal Kohistan wild life sanctuary and Sumbak, Surjan, Eri and Hothiano game reserves. The park provides refuge for several animals that include mammals, reptiles, birds and also variety of insects species. The dominant plants species of this area are *Euphorbia caducifola, Acacia jacquemontii, Acacia Senegal, Commiphora, Zizyphus nummularia, Grewia tenax and Blepharis sindica.* Base Line Environmental Study conducted by the University of Melbourne reported 475 types of plants in the area (Anonymous, 2000). KNP also supports a human population of around 55,000 as was estimated from a census in 1997/1998.

All forms of life are dependent on water for their existence. As a result of low average annual precipitation, and the concentration of rainfall in a short monsoon season, there are no permanent rivers in KNP. Through most of every year, groundwater discharging from natural springs or drawn from wells provides the only source of water for wild and domestic animals, irrigation and human use throughout the park.

This paper reports an assessment of groundwater in shallow aquifers, and the quality of water supplies in KNP. The technical paper is based on KNP Base Line Environmental Study (2000) conducted by University of Melbourne under the auspices of PKP Exploration Limited with the support of Sindh Wildlife Department, Government of Sindh.

MATERIALS AND METHODS

In February/March 2000, and in September 2000 an assessment was made of selected wells and springs in KNP. Table 1-2 lists the location of these sites. They were selected with the aid of a local guide on the basis of access from one of the park centres (Kharchat or Khar). The locations of major hydrological sampling sites are shown in Fig. 1.

For bacteriological analysis the water samples were collected in pre-sterilized bottles in a way to avoid possible contamination from the outside environment. Water samples were stored in a refrigerator as soon as possible after collection, but in some cases the delay was several hours. They were transported to Institute of Environmental Studies, University of Karachi with ice packed insulated containers for the following bacteriological analysis.

i. Total coliform count (TCC) ii. Total faecal coliform count (TFC) iii. Total faecal streptococci (TFS).

The samples were processed in laminar flow hood using sterilized culture media (the sterility of media was checked prior to use) by Most Probable Number (MPN) as per standard methods described in (APHA, 1998).

RESULTS AND DISCUSSION

Results of bacteriological analyses of water samples from wells and springs are presented in Tables 3 and 4 respectively. As such no previous data available pertains to public health quality of water resources at KNP. However, Rashid (1983) reported a preliminary investigation of the ground water potential of KNP.

Many of the wells had no lining at all, and others were lined only over the uppermost strata. The walls of several wells in the areas visited had collapsed and had been abandoned without back-filling. Near the Kharchat Centre, along the river course and at Kheiji there were groups of several wells with separations as little as 20 m. Village people reported that when one well was pumped, the water levels fell in nearby wells. A very large number of wells of various constructions were observed during the visits to KNP. However, some important sites were selected with the help of local guide (See Table 1, Fig.1).

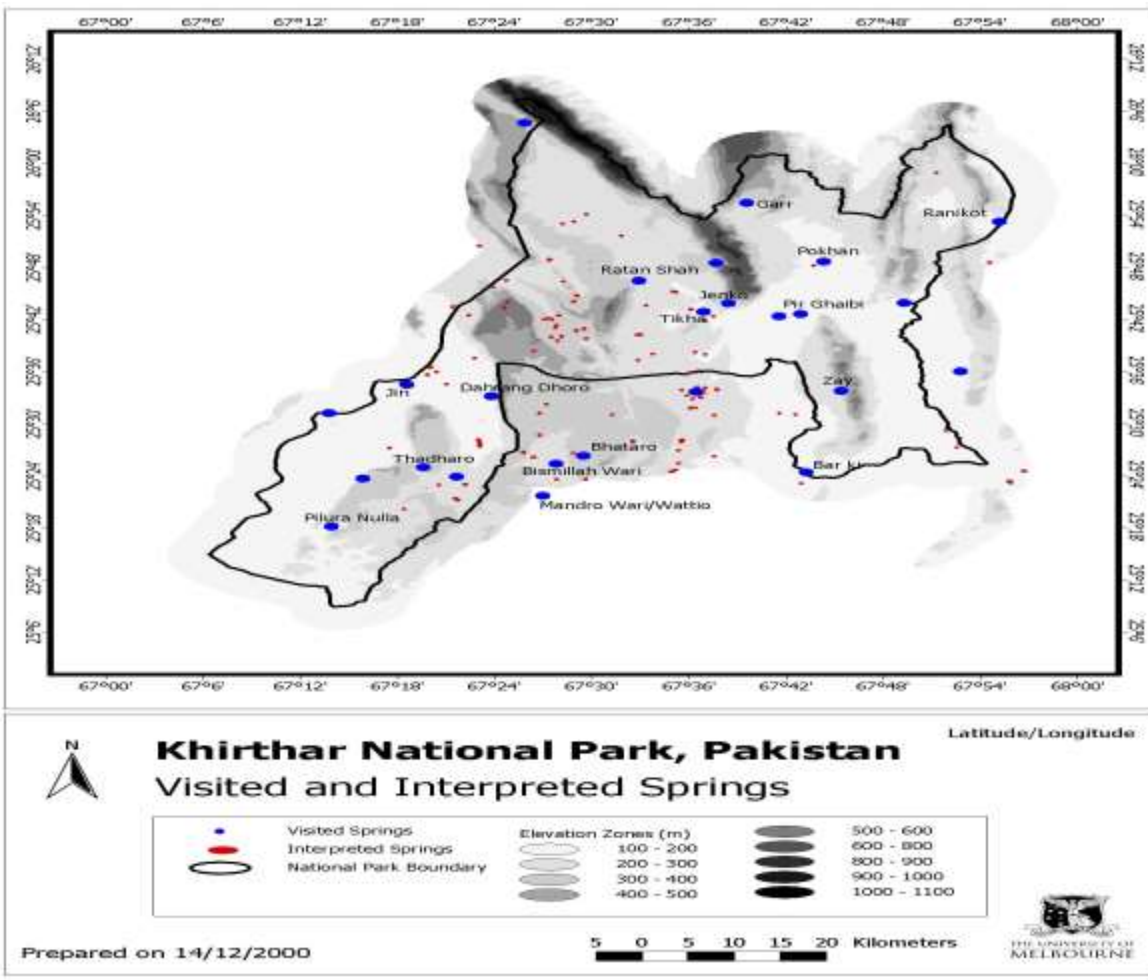

Fig 1. Important hydrological sampling sites at KNP

Most wells inspected in KNP were excavated to depths of only a few metres below the static water table with near vertical walls and plan-view areas of 10 to 20 m^2. It is understood that these wells were dug by hand.

The most common method for lifting water from a well in KNP is a diesel powered centrifugal pump mounted on the ground water surface. Water is generally delivered through galvanised steel pipe to a small reservoir for distribution by gravity to irrigated fields *via* an unlined surface channel system. Water for domestic use is taken from the surface reservoir or a channel in small containers. Other wells of smaller diameter were equipped with a windlass or simple rope and bucket for drawing water for domestic purposes.

Table 1. Sites of sample collection of well water at KNP

Sample No.	Date of sample collection	Location	Position on GPS		Population	Depth of well (m)	Diameter of well (m)	Water depth (m)	Major use	Area under cultivation (Hectare)
			East	North						
S-1	29-2-00	Karchat center.1	67.44	25.45	30-40	12.5	1.0	1.0	Domestic	Nil
S-2	29-2-00	Karchat center.2	67.44	25.445	250	100	0.4	12	Agriculture	10
S-3	1-3-00	Toung valley	67.3442	25.4620	50-60	100	0.5	14	Agriculture	8.0
S-4	1-3-00	Abdul Hakeem goth	67.308	25.5246	20	8.0	0.7	2.0	Domestic	Nil
S-5	1-3-00	Nabeel Khan goth	67.300	25.5742	8000	80	0.4	20	Domestic	Nil
S-6	2-3-00	Near Pokhan	67.4410	25.4843	10	30	1.0	2.5	Domestic/ Agriculture	2.0
S-7	2-3-00	Khaieji	67.4325	25.5110	1200	10	1.0	2.0	Agriculture/ Domestic	100
S-8	2-3-00	Khaieji	67.4325	25.5110	1200	10.2	1.0	3.0	Agriculture/ Domestic	100
S-9	2-3-00	Sukhnai river bed	67.4718	25.4550	20	8.0	2.0	2.0	Agriculture/ Domestic	2.0
S-10	2-3-00	Basra	67.476	25.4134	250	5.5	3.5	2.0	Domestic/ Agriculture	2.5
S-11	2-3-00	Kanra	67.4547	25.4314	500	11	3.5	2.5	Agriculture/ Domestic	20
S-12	3-3-00	Karchat centre	67.4354	25.4529	3000	100	0.5	3.0	Domestic	Nil
S-13	3-3-00	Khar centre	67.134	25.1737	10	30	2.5	1.0	Domestic	Nil
S-14	14-9-00	Tikko baran	67.308	25.5742	8000	80	0.4	20.0	Domestic	Nil
S-15	14-9-00	Toung valley	67.3442	25.4620	50-60	100	0.15	14.0	Agriculture/ Domestic	10.0
S-16	15-9-00	Khaieji	67.3432	25.5154	5000	11.5	3.0	1.5	Domestic/ Agriculture	1.0
S-17	15-9-00	Barki dhoro	67.4365	25.4695	Nil	9.5	7.0	5.0	Domestic/ Agriculture	1.0
S-18	16-9-00	Bhal area	67.4368	25.3454	400	35	1.0	0.4	Domestic	Nil
S-19	16-9-00	Saifal	67.4050	25.3749	500	36	3.2	1.0	Domestic	Nil
S-20	26-9-00	Khar centre	Not available	Not available	20	100	0.5	15	Agriculture	15

The wells are often surrounded by a low bund of excavated material that would restrict the entry of surface water to the well. In some cases there is also a brush fence to prevent animals from possibly falling into the well. Generally, however, there are no effective measures to prevent contamination of water in the dug wells.

Several boreholes (locally called tube wells) were inspected in Khirthar National Park. These were said to have been drilled with diameters of around 300 mm to depths of around 100 m, and constructed with 200 mm diameter casing and wire-wound screens. Boreholes were generally equipped with turbine pumps driven by a diesel engine, but in two cases an electric submersible pump was installed together with a diesel-electric set.

Water is generally delivered from a borehole through galvanized steel pipe to a small ($<1\ m^3$) reservoir for distribution by gravity to irrigated fields *via* a surface channel system. However, at Kharchat Village, a borehole drilled with the aid of a government grant delivers water to the village *via* a piped system. Water is also reticulated through piped systems at the Khar and Kharchat Centres. Construction of the boreholes was suitable to prevent the entry of surface water that could be a source of contamination. Water from only one of the wells (Karchat Village) met the WHO guidelines (1996) for drinking at the time of sampling. It is notable that the well providing water that was acceptable for drinking was drilled to a depth of 80 m or more.

Table 2. Sites of sample collection of spring water at KNP

Sample No.	Date of sample collection	Name of spring	Position on GPS		Population	Flow m^3/d	Major use
			East	North			
S-21	23-2-00	Jenko	67.6413	25.7304	Nil	Nil	Wild life
S-22	25-2-00	Pokhan	67.7390	25.8106	Nil	2200	Irrigation
S-23	14-9-00	Ratan Shah 1	67.3556	25.4628	1000	7200	Domestic
S-24	14-9-00	Jin	67.31	25.5742	Nil	2000	Domestic
S-25	14-9-00	Ratan Shah 2	67.3329	25.4627	1000	5000	Irrigation
S-26	14-9-00	Tikha	67.6149	25.7143	Nil	10000	Wetland
S-27	14-9-00	Jenko	67. 6413	25.7304	Nil	Nil	Wildlife
S-28	14-9-00	Pir Ghaibi	67.6926	25.7057	150	6500	Domestic
S-29	15-9-00	Dahrang Dhoro	67.3972	25.5527	800	Nil	Domestic
S-30	15-9-00	Bismillah Wahi	67.4637	25.4226	500	Nil	Domestic
S-31	15-9-00	Bhataro	67.4930	25.4382	100	2200	Irrigation
S-32	16-9-00	Mandro Wahi	67.4497	25.3616	Nil	300	Wildlife
S-33	16-9-00	Wattio	67.4498	25.3616	Nil	Nil	Domestic
S-34	16-9-00	Zay	67.4540	25.3378	Nil	Nil	Wild life

All the well water samples were reported to be contaminated with the organisms of public health importanc (Table 3). The total coliform cpont (TTC) in the wells ranged between < 3 to 2400, total facial coliform count (TFC) between < 3 to 2400 and total faecal streptococci (TFS) between < 3 to ≥ 2400, respectively. With respect to TCC, TFC and TFS there was no significant difference between wells and springs. However, when wells < 80 m deep were compared to those 100 m deep it was found that they differ significantly in TCC ($p < 0.01$) (mean TCC for < 80 m wells 130.4 ± 84.82 and for 100m deep wells (1356.26 ± XXX.) and in TFS ($p < 0.05$) (mean for < 80 m deep wells 94.6 ± 91.35 and for 100m deep wells 1260 ± 293.87). To seek any underlying relationship between flow rate of springs and the bacterial counts Pearson's product moment correlation coefficients were computed. All correlations were found to be non-significant (flow arte and TCC, $r = 0.180$; flow rate and TFC, $r = -0.031$; flow rate and TFS, $r = -0.314$). Meyberk, (1985) reported that the fecal coliforms up to 10^6/100ml are commonly found in Pakistan, India, Indonesia and Pakistan. These organisms are the continuous source of ailment in the local people of KNP. Gumbo (1985) reported that infectious water related diseases are most important in the developing countries. KNP people have no exception as depicted from the conversation with local people. Gumbo also reported that unless drinking water supplies are improved there is a little hope of controlling communicable diseases in the population.

The springs of Khirthar National Park are geologically and topographically controlled areas of groundwater discharge that provide natural sources of water for wildlife, and support local ecosystems that may be of considerable importance in an arid environment. Water is diverted from some springs for irrigation of nearby fields and for domestic use in some villages. Several springs in KNP were inspected on the ground, and the location of other pools of surface water that may be springs was inferred by interpretation of satellite imagery (LANDSAT 5 on 24 September 1994). This process depends on identification of a unique spectral signal for pools of surface water from the various wavebands of radiation detected by the satellite. Pools that are smaller than a single pixel of the imagery (in this case 30 m by 30 m), or that cover parts of several pixels do not present a unique signal and they are unlikely to be identified by this procedure. Moreover, the interpretation process cannot distinguish between springs and pools of surface water remaining after heavy rain that is believed to have fallen in KNP in August 1994.

Table 3 Results of bacteriological analysis of well water samples at KNP

Sample No.	Date of sample collection	Location	Bacteriological analysis				
			TCC MPN/100ml	TFC MPN/100ml	TFS MPN/100ml	Remarks	WHO guidelines
S-1	29-2-00	Karchat center.1	4	4	<3	UFHC	<3
S-2	29-2-00	Karchat center.2	<3	<3	<3	FHC	<3
S-3	1-3-00	Toung valley	460	460	21	UFHC	<3
S-4	1-3-00	Abdul Hakeem goth	75	9	<3	UFHC	<3
S-5	1-3-00	Nabeel Khan goth	9	<3	<3	UFHC	<3
S-6	2-3-00	Near Pokhan	≥ 2400	≥ 2400	240	UFHC	<3
S-7	2-3-00	Khaieji.1	≥ 2400	≥ 2400	460	UFHC	<3
S-8	2-3-00	Khaieji. 2	2400	1100	40	UFHC	<3
S-9	2-3-00	Sukhnai river bed	460	460	15	UFHC	<3
S-10	2-3-00	Basra	93	23	1100	UFHC	<3
S-11	2-3-00	Kanra	≥ 2400	≥ 2400	≥ 2400	UFHC	<3
S-12	3-3-00	Karchat centre	<3	<3	<3	FHC	<3
S-13	3-3-00	Khar centre	43	43	23	UFHC	<3
S-14	14-9-00	Tikko baran	460	460	28	UFHC	<3
S-15	14-9-00	Toung valley	93	4	<3	UFHC	<3
S-16	15-9-00	Khaieji	≥ 2400	≥ 2400	≥ 2400	UFHC	<3
S-17	15-9-00	Barki dhoro	≥ 2400	≥ 2400	460	UFHC	<3
S-18	16-9-00	Bhal area	≥ 2400	≥ 2400	≥ 2400	UFHC	<3
S-19	16-9-00	Saifal	≥ 2400	≥ 2400	≥ 2400	UFHC	<3
S-20	26-9-00	Khar centre	93	<3	<3	UFHC	<3
Minimum- Maximum			<3---≥ 2400	<3---≥ 2400	<3---≥ 2400	UFHC	<3

Table 4 Results of bacteriological analysis of water samples from springs at KNP.

Sample No.	Date of sample collection	Location	Bacteriological analysis				
			TCC MPN/100ml	TFC MPN/100ml	TFS MPN/100ml	Remarks	WHO guidelines
S-21	23-2-00	Jenko	150	93	≥ 2400	UFHC	<3
S-22	25-2-00	Pokhan	240	240	<3	UFHC	<3
S-23	14-9-00	Ratan Shah 1	≥ 2400	≥ 2400	9	UFHC	<3
S-24	14-9-00	Jin	≥ 2400	≥ 2400	≥ 2400	UFHC	<3
S-25	14-9-00	Ratan Shah 2	≥ 2400	≥ 2400	1100	UFHC	<3
S-26	14-9-00	Tikha	9	4	<3	UFHC	<3
S-27	14-9-00	Jenko	150	93	≥ 2400	UFHC	<3
S-28	14-9-00	Pir Ghaibi	23	9	9	UFHC	<3
S-29	15-9-00	Dahrang Dhoro	1100	1100	240	UFHC	<3
S-30	15-9-00	Bismillah Wahi	≥ 2400	≥ 2400	43	UFHC	<3
S-31	15-9-00	Bhataro	1100	1100	93	UFHC	<3
S-32	16-9-00	Mandro Wahi	≥ 2400	≥ 2400	460	FHC	<3
S-33	16-9-00	Wattio	2400	460	240	UFHC	<3
S-34	16-9-00	Zay	1100	460	93	UFHC	<3
Minimum- Maximum			<3---≥ 2400	<3---≥ 2400	<3---≥ 2400	UFHC	<3

Any discharge from a spring was computed from the velocity of flow (estimated by the rate of movement of a small piece of wood or grass) and the cross sectional area of the stream channel in a section where flow was relatively straight and steady.

Table 2 presents estimated rates of discharge from springs. The flow from around 50% of them was negligible. Flow from the remaining springs was varying ranging up to an estimated 10 $m^{-3}d^{-1}$. The large flow from several springs indicates very high transmissivity of the aquifer in these areas. Large channels (karst formations) are exposed in limestone above the water line in Pir Ghaibi Spring. None of the springs that were inspected was protected in any way from contamination of the water after it had been discharged from the aquifer. Whilst this may be unimportant where water is used for irrigation or as a water supply for animals, there is a potential for bacteriological contamination that may affect quality as a drinking water supply for people. These results show that on the basis of WHO guidelines, water from the springs was not suitable for drinking at the time of sampling (Table 4). Llyod *et al.,* (1989) reported that in rural environment protection of spring water can readily reduce the level of fecal contamination by almost two order of magnitude. These values represent the average reductions and there is no guarantee that any source will remain with the low level of contamination throughout the year.

Agriculture runoff, sewage leaks, and metals however quite often contaminate this source. However, users have no method to judge its quality except for taste. Thus, most of the residents drink polluted water unknowingly, and do not question its quality.

CONCLUSION

The study reveals that the water quality in KNP does not meet the WHO guide lines (1996). From the paint of view of quality and quantity the KNP faces critical problems arising from the following causes.

i. The population of KNP is currently growing at an accelerated rate largely by invasion of district areas on the fringe of the city.
ii. There is negligible rainfall through out the year and therefore no effective recharge of the ground water.
iii. The ground water level is falling at an alarming rate; several meter per year. This is further aggravated by the use of water for agricultural purposes by the local peoples

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