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Status of drinking water quality in western part of the Thar desert, Sindh, Pakistan

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ABSTRACT: *In Thar Desert, which is one of the most densely populated desert of the world, the primary source of water is dug well. Water available from these dug wells is suspected to be unfit for drinking. Samples of water from the western part of Thar desert were analyzed for anions, cations and trace metals. The data show elevated levels indicating hazardous nature of drinking water. Therefore, it is recommended that appropriate measures should be taken for the supply of clean drinking water to the inhabitants of this densely populated desert of the world.*

INTRODUCTION

The world densely populated Thar Desert is situated in the central portion of Sindh and is a part of larger desert extending into India (Fig. 1). Thar Desert is bounded by Indian border in the north, south and east and by the flood plains of Indus river in the west. People are mainly settled in the areas where groundwater is available. The economy of Thar depends on grazing livestock. In limited areas cultivation is rain water dependent where Bajra is the main crop. However, Till, Sarseem, Jambho and Castor are also grown.

Dug wells are the primary sources of water which is generally salty and unpalatable. Soon after monsoons, relatively fresh and potable water is available from shallow wells. However, in general water is obtained from wells 200 to 300 feet deep. This water is mostly brackish and salty. Hakra river is considered to have fed this deep aquifer untill the start of 14th century (Panhwar, 1986). Since then no replenishment has occurred and thus the original sweet water turned brackish which is unusable for irrigation and drinking. This type of water may cause health related hazards in the area. The current studies have been carried out in order to determine the quality deterioration of the drinking water in Thar Desert on the basis of geochemical data.

GEOLOGY OF THE AREA

Geology of the Thar Desert remains obscure because sand dunes of at least 80m thickness cover most of the area. The only outcrop of rocks is exposed at Nagar Parker, which dominantly consists of granite with minor amount of rhyolite and other metamorphic rocks (Fessett & Durrani, 1994). 3000m deep exploration well, drilled at the western edge of the desert at Nabisar, has unraveled Triassic, Jurassic, Cretaceous, Paleocene, Eocene and post Eocene rocks (Ahmad & Zaigham, 1993). Recently a giant coal field with an area of 9000 km^2 and a total field tonnage of 78,196,555,800 metric tones has been discovered in Thar (Fassett & Durrani, 1994). On the basis of paleontological data these coal deposits have been dated as of Paleocene to Eocene age, deposited in a raised-bog environment landward east of a north-trending coastline (Fassett & Durrani, 1994).

RESULT AND DISCUSSIONS

Water samples for the present investigations were collected from dug wells at Kangoro, Digri, Wijooto, Mithi and Diplo. Samples of canals which are the dominant source of water in western part of the desert were collected from Nara and Jamro canals and their tributaries at Mirpurkhas, Kangoro, Digri, Jhudo and Naukot (Fig. 1).

Both physical and chemical analyses of each sample of water were carried out in the field and laboratory. Physical analyses included determination of pH and conductivity. Whereas, chemical analyses included, determination of anions [sulfate (SO_4), nitrate, (NO_3), chloride (Cl), carbonate (CO_3), bicarbonate (HCO_3)], and cations [calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), iron (Fe), manganese (Mn), lead (Pb), nickel (Ni), chromium (Cr), copper (Cu) and cadmium (Cd)]. Anions were determined in the field by using DR-2000 Hach photometer. The remaining metals and non-metals were determined by Perkin Elmer-3300 Atomic Absorption, equipped with HGA 600 graphite furnace, in the National Center of Excellence in Geology, University of Peshawar. Fluoride was of particular concern which was determined by the method of SPANDS as recommended by American Public Health Association (1985).

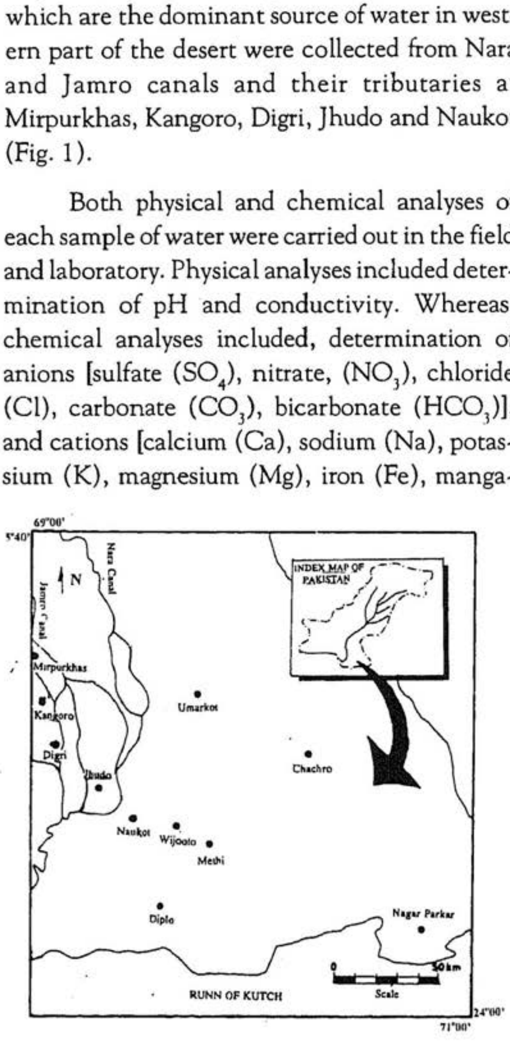

Fig. 1. Location map of Thar desert.

The chemical data obtained for surface and ground water (Tables 1&2) are classified by using Piper diagrams (Fig. 2). According to this scheme the dug wells data from Digri fall in the field of sodium-potassium, chloride-sulphate type normally called as alkaline earth fresh water and those from Wijooto fall in the field of calcium-magnesium, bicarbonate field named as alkaline fresh water. Water samples of Methi fall in the compositional range of chloride-sulfate type, while water of Diplo is sodium-potassium, chloride-sulphate type. In general it appears that the studied water samples show alkali enrichment, indicating increased evaporation and saturation of alkalis in water. Water samples of Nara and Jamro canals at Mirpurkhas and Digri fall in the field of sodium-potassium, chloride-sulphate type. The water samples of canal at Jhudo, Naukot and Kangoro fall in the field of calcium-magnesium, bicarbonate type. This suggest that water samples collected from Nara and Jamro canals and their tributaries show a general change from alkaline earth fresh water with higher content of alkalis to alkaline fresh water while moving from north (Mirpurkhas) to south (Naukot).

Results of the chemical analyses for each dug well along with World Health Organization (WHO) (1984) Maximum Contaminant Levels (MCLs) and charge balance are given in Table 1. Analyses of TDS, SO_4, NO_3, F, Cl, Na, Fe and Mn

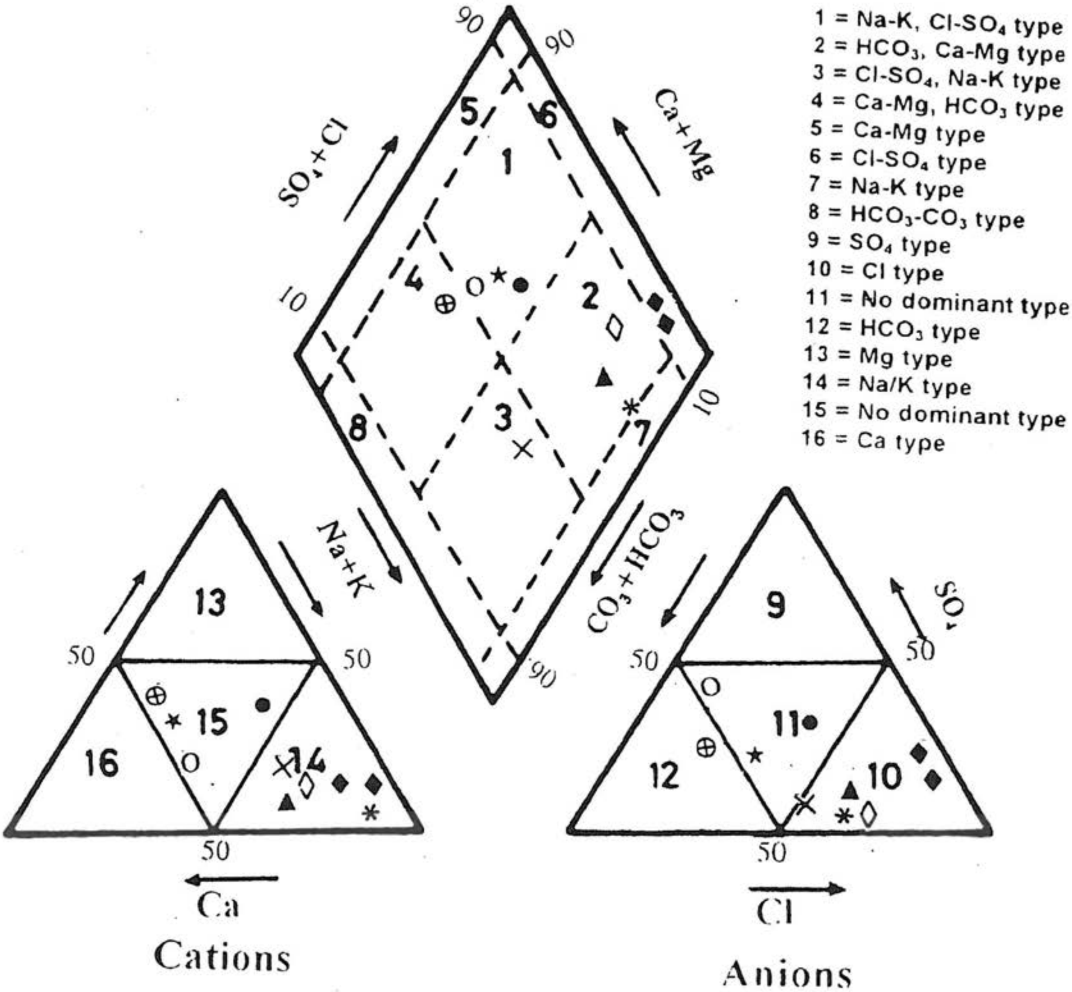

Fig. 2. Water classification of Thar area by Piper Scheme.
Dug wells samples: • = Digri, ✱ = Wijooto, ◆ = Methi, × = Diplo; Canal water samples: ◊ = Jhudo, O = Mirpurkhas, ▲ = Naukot, ⊕ = Kangoro, ★ = Digri

are compared with Maximum Contaminant Level (MCL) of WHO (1984) in Figure 3. It is clear from this figure that the water from deep level (Methi2) at Methi has relatively high TDS, NO_3, F and Na and lower Fe and Mn than the MCL of WHO. However, shallow water (Methi1) at Methi has higher TDS, SO_4 and Na and lower concentration of the remaining as compared to MCL. The water from dug well at Digri has high Fe; the dug well at Diplo has high TDS, Cl, F and Na and that at Wijooto has high TDS, Fe and Mn contents. This shows that the water of Methi (deep level) and Diplo is the most contaminated in regard to TDS, NO_3, F, Cl and Na. This may cause cardiovascular diseases, diarrhea, methemoglobinemia and fluorosis (NAS,1974).

TABLE 1. GEOCHEMISTRY OF DRINKING WATER SAMPLES OF THAR AREA, COLLECTED FROM DUG WELLS

S. No		1	2	3	4	5
Location	WHO	Digri	Wijooto	Methi 1 (Shallow)	Methi 2 (deep)	Diplo
TDFS (mg/L)	1000	245	1057	1155	6846	2142
pH	6.5-8.5	7.79	7.65	8.01	7.77	7.0
SO4 (mg/L)	400	47	36	625	275	50
NO3 (mg/L)	45	0	12	17	90	70
PO4 (mg/L)	—	0.10	0.73	0.55	0.31	0.28
HCO3 (mg/L)	—	70	349	290	44	158
Cl (mg/L)	250	48	246	38	25	649
F (mg/L)	1.50	0.00	0.40	0.20	3.10	7.50
Ca (mg/L)	—	3	46	19	48	43
Mg (mg/L)	—	17	28	11	112	43
Na (mg/L)	200	32	164	291	1730	451
K (mg/L)	—	2	73	85	41	12
Fe (mg/L)	0.30	1.00	2.25	0.06	0.01	0.37
Mn (mg/L)	0.06	0.06	0.17	0.18	0.05	0.05
Pb (mg/L)	0.05	0.12	0.08	0.22	0.38	0.18
Ni (mg/L)	0.05	0.18	0.08	0.07	0.14	0.08
Cd (mg/L)	0.005	0.000	0.000	0.000	0.003	0.001
Cu (mg/L)	1.00	0.18	0.07	0.03	0.06	0.1
Cr (mg/L)	0.05	0.12	0.00	0.18	0.13	0.08
Zn (mg/L)	5.00	0.15	0.01	0.05	0.01	0.12
Total cations (meq/L)		3.56	13.72	16.55	88.04	25.68
Total anions (meq/L)		3.45	13.74	16.70	90.06	26.64
Charge balance (%)		1.57	-0.5	-0.45	-1.13	-0.96

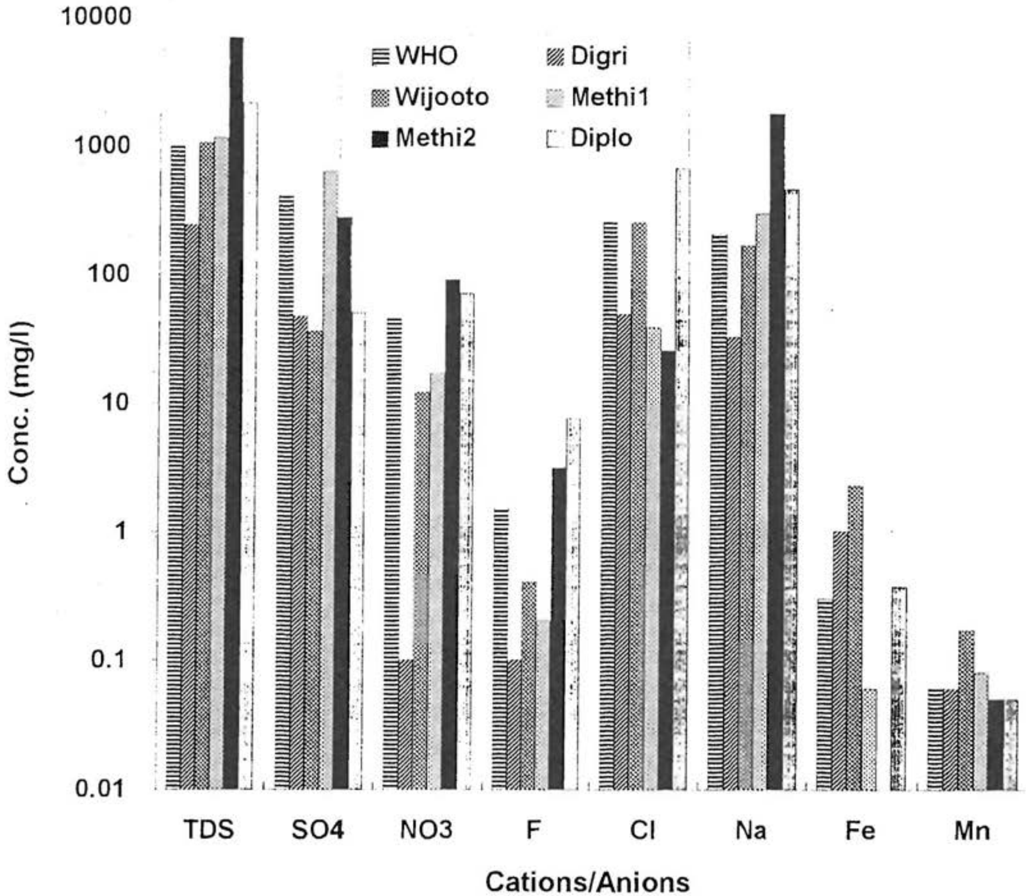

Fig. 3. Comparison of various cations and anions of the water samples of studied dug wells with MCL of WHO.

Trace elements (Pb, Cd, Cr, Zn & Cu) of the dug wells are compared with MCL of WHO (1984) in Figure 4. Lead contents in almost all the analyzed samples are higher than the MCL of WHO. Chromium concentrations in all the samples of well water (except at Wijooto) are higher than the permissible limit (Fig. 4) compared to that of the MCL of WHO (Fig. 4). It is highest (0.18 mg/L) at Methi1 followed by Methi2 (0.13mg/L) and Diplo (0.12 mg/L). These high concentrations of lead and chromium can be considered as carcinogenic and their amount exceeding the permissible limit in drinking water of the area could be dangerous for health of the inhabitants (see NAS, 1974). Cadmium concentration in the studied dug well samples is in the range of 0 to 2.4 ug/L and is within the MCL of WHO. Sample collected from deeper level of Methi (Methi2) has relatively high cadmium (2.4 ug/L) while that of shallow depth (Methi1) has negligible cadmium concentration (Table 1).

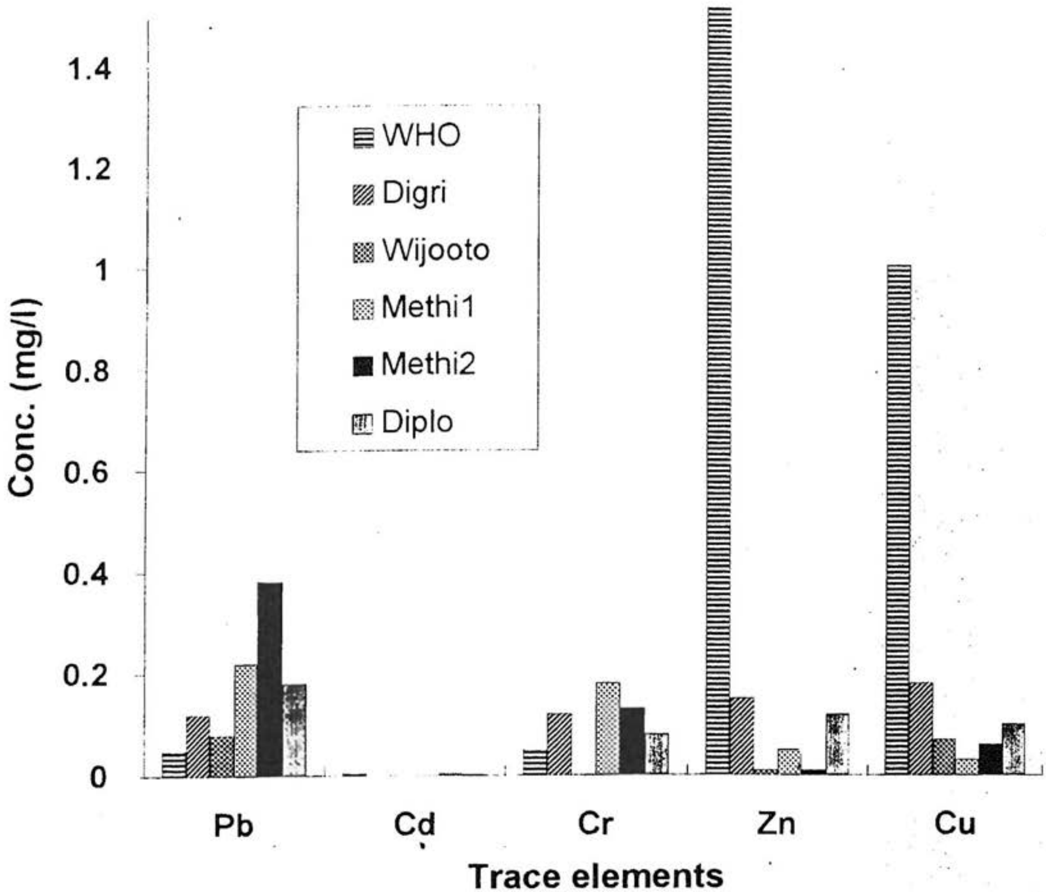

Fig. 4. Comparison of various trace elements of the water samples of studied dug wells with MCL of WHO.

Western part of the studied area is irrigated by Nara and Jamro canals (Fig. 1). Nara canal has inflow of water from the Indus river at Sukhur Barrage. While Jamro canal is one of the major branches ofNara canal. Most of the population in the Nara command area are dependent upon the water of Nara canal for the agriculture and domestic use. Samples from Nara and Jamro canals were collected at Mirpurkhas, Kangoro, Digri, Jhudo and near Naukot. Analyses of the water samples are given in Table 2 and are presented graphically in Figures 5 and 6. It is clear from figure 5 that TDS, SO_4, NO_3, Cl and Na are below while fluoride, iron and manganese are above the MCL of WHO. However, a canal sample from Digri has lower fluoride content than MCL of WHO. The high concentration of iron and Mn may cause taste problem in the drinking water. It is clear from Figure 6 that Pb in almost all the samples while chromium in two samples (i.e., at Mirpurkhas and Digri) are above the MCL of WHO. The rest of the samples have low Chromium contents. Copper and Zinc in all the samples of these canals are within the permissible limit (Fig. 6).

TABLE 2. CHEMICAL DATA OF WATER SAMPLES OF CANALS IN THAR AREA

S. No		1	2	3	4	5
Location	WHO	Mirpurkhas	Kango	Digri	Jhudo	Naukot
		Jamrao			Nara canal	
TDFS (mg/L)	1000	259	238	224	203	252
pH	6.5-8.5	7.83	7.5	7.8	7.2	7.64
SO4 (mg/L)	400	65	43	38	17	36
NO3 (mg/L)	45	0.6	1.4	2.5	0.4	0.2
PO4 (mg/L)		0.08	0.11	0.45	0.11	0.14
HCO3 (mg/L)		109	122	0	144	120
Cl (mg/L)	250	14	48	42	211	197
F (mg/L)	1.5	2.93	4.7	0.05	4.6	0.4
Ca (mg/L)		30	30	31	33	32
Mg (mg/L)		11	13	13	12	10
Na (mg/L)	200	23	20	23	14	13
K (mg/L)		4.6	6.2	4.6	4.1	3.4
Fe (mg/L)	0.30	0.81	0.02	1.08	1.35	0.01
Mn (mg/L)	0.06	0.07	0.1	0.06	0.07	0.06
Pb (mg/L)	0.05	0.25	0.08	0.23	0.21	0.06
Ni (mg/L)	0.05	0.09	0.00	0.00	0.00	0.05
Cd (mg/L)	0.005	0.000	0.001	0.000	0.003	0.001
Cu (mg/L)	1.00	0.04	0.05	0.06	0.07	0.02
Cr (mg/L)	0.05	0.18	0.04	0.2	0.03	0.04
Zn (mg/L)	5.00	0.00	0.01	0.02	0.03	0.00
Total cations (meq/L)		3.48	3.61	3.7	8.93	8.13
Total anions (meq/L)		3.49	3.66	3.44	8.72	8.31
Charge balance (%)		-0.14	-0.69	3.6	1.19	-1.09

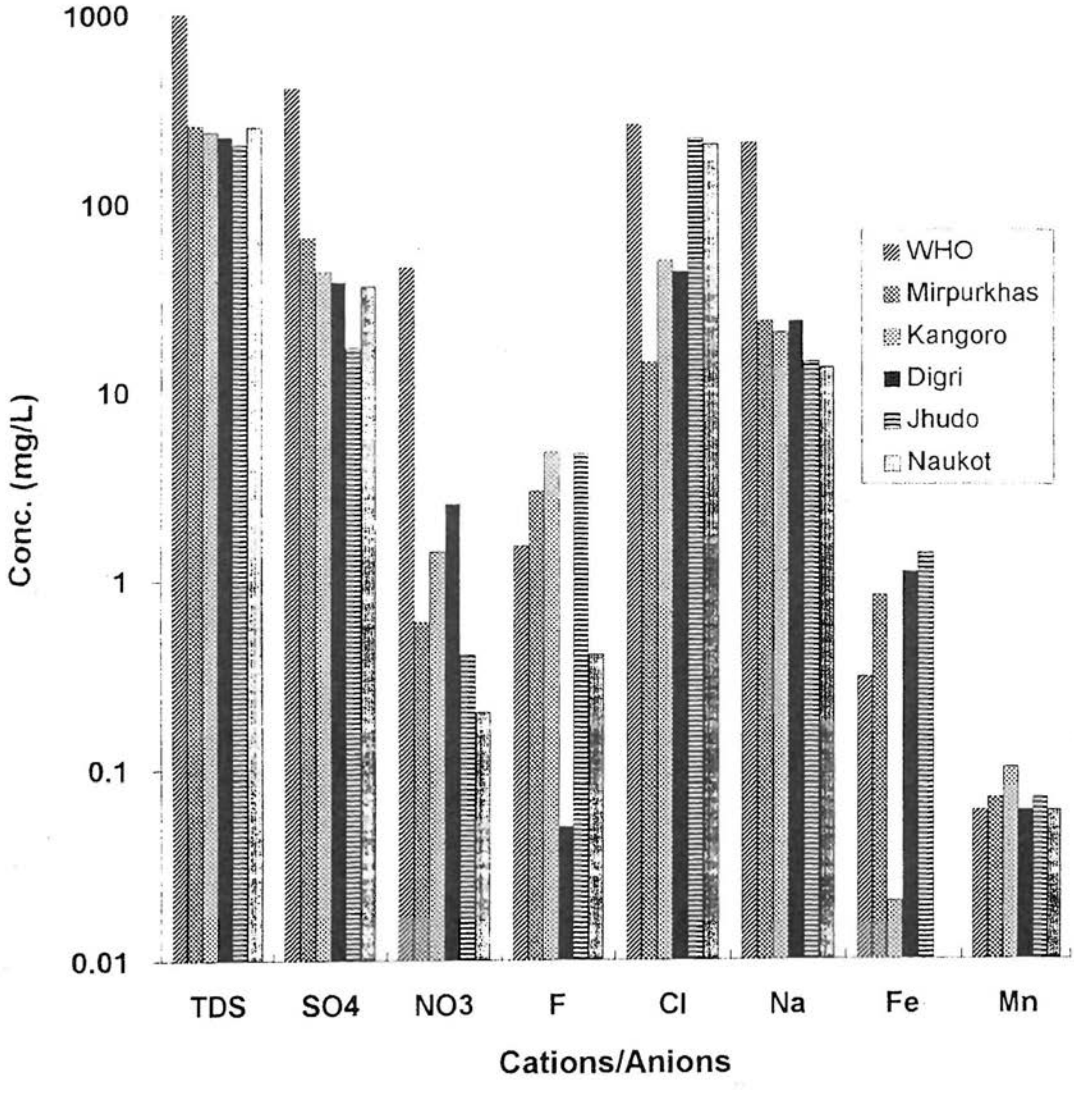

Fig. 5. Comparison of various major cations and anions of the water samples of Nara and Jamro canals with MCL of WHO.

CONCLUSIONS / RECOMMENDATIONS

1. Both surface and groundwater of the area have alkali enrichment trend and is, therefore, classified as alkaline.

2. Elevated levels of TDS, SO_4, NO_3 and F content are found in the dug well samples of the studied area and may, therefore, cause diseases like cardiovascular, diarrhea, methemoglobinemia and fluorosis among the inhabitants of the area..

3. Lead and chromium are in higher concentration than the permissible limit, which is ex-

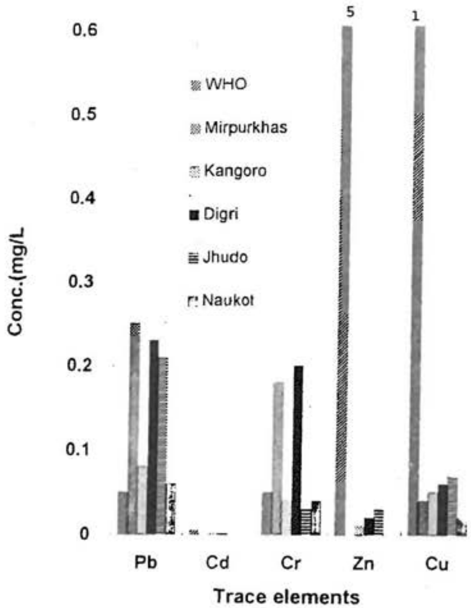

Fig. 6. Comparison of various trace elements of the water samples of Nara and Jamro canals with MCL of WHO.

tremely dangerous as these trace elements are found to be carcinogenic.

4. Copper, zinc and cadmium in drinking water are within the permissible limits and could be harmless.

5. It is recommended that the detail geochemical investigations of water and soil of the whole Thar region should be carried out. This will pin point the areas of high toxicity where remedial measures should be adopted in order to provide clean drinking water to the inhabitants of the region.

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