DRINKING WATER QUALITY CHALLENGES IN PAKISTAN

By

Z. A. Soomro[1], Dr. M. I. A. Khokhar, W. Hussain and M. Hussain

Abstract:
Pakistan is facing drastic decrease in per capita water availability due to rapid increase in population. The water shortage and increasing competition for multiple uses of water has adversely affected the quality of water. Pakistan Council of Research in Water Resources has launched a national water quality monitoring program. This program covered water sampling and their analysis from 21 major cities. The water samples were analyzed for physical, chemical and bacteriological contamination. Results showed that most of the samples in all four provinces are microbiologically contaminated. Arsenic problem is major in cities of Punjab, Nitrate contamination in Balochistan, Iron contamination in KPK and higher turbidity values found in water samples found in Sindh. This valuable data would serve the regulatory bodies and implementing authorities towards the quality drinking water supply.

Key words: Water Quality, Surface water, Groundwater contamination, Hand pumps, Pollution, Microbiology, Chemical contamination.

1. INTRODUCTION

Nature has blessed Pakistan with adequate surface and groundwater resources. However, rapid population growth, urbanization and the continued industrial development has placed immense stress on water resources of the country. The extended droughts and non-development of additional water resources have further aggravated the water scarcity situation. Pakistan has been blessed with abundance of availability of surface and ground water resources to the tune of 128300 million m^3 and 50579 million m^3 per year respectively (The Pakistan National Conservation Strategy, 1992).Consequently per capita water availability has decreased from 5600 m^3 to 1000 m^3 / annum(Water quality status 2003). The increasing gap between water supply and demand has led to severe water shortage in almost all sectors. The water shortage and increasing competition for multiple uses of water adversely affected the quality of water. In this regard, the results of various investigations and surveys by several agencies had indicated that water pollution has become a serious problem in Pakistan. Most of the reported health problems are directly or indirectly related to water. The quantitative and qualitative concerns of water call for an action plan for efficient development, utilization and monitoring of the water resources of the country.

Results from various investigations and surveys indicate that water pollution has increased in Pakistan. The pollution levels are higher particularly in and around the big cities of the country where cluster of industries have been established. The water quality deterioration problems are caused by the discharge of hazardous industrial wastes including persistent toxic synthetic organic chemicals, heavy metals, pesticide products

---

1. Pakistan Council of Research in Water Resources, Lahore – Pakistan.

and municipal wastes, untreated sewage water to natural water bodies. These substances mixed with water then cause widespread water-borne and water-washed diseases.

The World Health Organization (WHO, 1972-73) estimates that 500 million diarrhea cases reportedly take place each year in children less than five years in Asia, Africa and Latin America. The extent of enteric diseases in different areas depends upon the extent to which water is exposed to contamination. The incidence of typhoid fever, bacillary dysentery, infectious hepatitis and other enteric infections are common and are transmitted through contaminated water. Cholera is still a wide spread water borne disease in some developing countries. There are numerous other diseases that are transmitted through polluted water. It has been shown that cancer may be caused by the accumulation of certain materials carried out by water to human organs (DAWN, 1989). The excess of cadmium accumulated in the kidney causes hypertension as is evident from study conducted on animals.

Unsafe drinking water is a major cause of the disease, which otherwise may be prevented, in particular in young children in developing countries. Pathogens present in drinking water including many viral, bacterial and protozoan agents cause 2.5 million deaths from endemic diarrhoeal disease each year (Kosek *et al.* 2003).

PCRWR (1985) and WHO (1972-73) reported that after installation of new water supply pipes alone in 30 rural settlements of Japan, communicable intestinal diseases were reduced by 72% and that of trachoma by 64% while the death rate for infants and young children fell by 52%. Similarly in Uttarpardesh (PCRWR, 1985) after carrying out improvements in water works, sewerage, and sanitation, the cholera death rate decreased by 74%, typhoid fever death rate by 63.3%, and dysentery death rate by 23%. Additionally, 10% productive time of each person, wasted due to water-related diseases, can also be saved.

The quality of water supplies in many cities of Pakistan is deteriorating fast. The primary source of these supplies is groundwater. As a result, one hundred million cases of diarrhea are being registered for treatment in hospitals of Pakistan each year (WHO, 1972-73). A survey conducted by PCRWR (Tahir, M.A. et al., 1994) showed that 81,996 cases of water related diseases were registered in Basic Health Units of Rawalpindi Division alone. According to United Nations Children's Fund (UNICEF), 20% to 40% beds are occupied in the hospitals of Pakistan by patients suffering from water related diseases. Diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis, cryptosporidiosis and guinea worm infections are about 80% (including diseases due to sanitation problem) of all diseases and are responsible for 33% of deaths (Tahir, M.A. et al., 1994).

Considering the deteriorating water quality status, the Pakistan Council of Research in Water Resources (PCRWR) has launched a National Program for monitoring the quality of water in Pakistan. The main objective of the water-quality monitoring project is to establish a permanent water quality-monitoring network in the country to observe changes in surface and groundwater quality as well as groundwater levels. The monitoring results would lead to remedial measures for improving the quality and

sustainable use of the water resources. The project is designed to monitor quality of drinking water from twenty-one cities in the country, out of which 11 cities are from Punjab, 3 from Sindh, 4 from Balochistan and 3 from NWFP. Apart from this, six main rivers, five dams, two reservoirs, three natural lakes and two major drains, are also included in the national water quality monitoring program. This gives a reasonable coverage of the country's water resources. In the current paper, we have discussed the water quality status of 21 cities across the country and the major contaminants.

2. METHODS AND MATERIALS

2.1. Sampling Methodology

For the collection of water samples, a uniform grid size of 1 km^2 (for small size cities), 4 and 9 km^2 (for medium size cities) and, 16 and 25 km^2 (for big size cities) was used. One sampling point in each grid was selected for collection of water samples. In this regard, preference was given to permanent public water points considering the long term monitoring requirement of the project. The samples were collected before monsoon season. The sample size, collection, preservations and analysis were conducted according to the standard methods for water quality testing. The sources of water samples were from tap water, tube wells, dug wells and hand pumps.

2.1.1. Sample Collection Procedure:

Water samples for Physical and Chemical analysis were collected in polystyrene bottles of 0.5 and 1.5 liter capacity. Before collecting the water samples, the bottles were washed properly and rinsed thoroughly several times, first with distilled water and then with sample water. For bacterial analysis, samples were collected in sterilized container. Hydrochloric acid and boric acid were used as preservatives in sampling bottles, for trace elements and nitrate as nitrogen respectively. For physico-aesthetic and basic chemical analysis, no preservative was used.

2.1.2. Aesthetic, Physical and Chemical Contamination Parameters

Standard methods were adopted for the analysis of aesthetic, physical, chemical and microbiological water quality parameters. The details of these parameters and the standard methods used for analysis of these study parameters are given in
Table-1 . Each water sample was analyzed for 23 water quality parameters including Arsenic, Fluoride, Nitrate, Iron and Microbiological contamination. Details of methods of analysis for 9 selected parameter based on their health effects are given as follows;

Table-1: Water Quality Parameters and Methods used for Analysis

S. #	Water Quality Analysis Parameters	Test Methods
1.	Potassium (mg/l)	Flame Photometer PFP7, UK
2.	Sodium (mg/l)	Flame Photometer PFP7, UK
3.	TDS (mg/l)	2540C, Standard Method (1992)
4.	Turbidity (NTU)	Turbidity Meter, Lamotte, Model 2008, USA
5.	Fluoride (mg/l)	4500-FC, ion-selective electrode method, Standard Method 1992

6.	Nitrate-N (mg/l)	Cd. Reduction (Hach-8171) by spectrophotometer
7.	Iron (mg/l)	TPTZ method, Hach Cat. 26087-99)
8.	Arsenic (μg/l)	Atomic Absorption Spectrometer, Vario6, Analytikjena AG
9.	Microbiological Analysis	9221-B,E. Multiple tube fermentation technique, Standard methods for the examination of the water and waste water

2.2. Water Quality Parameters Analysed

The water samples were analyzed for physical, chemical and bacteriological contamination. The physical and aesthetic analysis of water covered color, electrical conductivity, odor, pH, taste and turbidity. The chemical quality included the analysis of water for 18 chemical parameters. The water samples for bacteriological quality were analyzed for E-coli and coliform contamination. In the present paper, following nine parameters are being discussed which have adverse health effects specifically in drinking water.

Table-2: Water quality parameters, their permissible limits and health effects due to their presence beyond limit.

Sr. No	Contaminants	Permissible Limits	Health Effects
1	Bacterial Contamination	0(WHO)	Diarrhea, Dysentery, Typhoid, Cholera, Hepatitis, Stomach, Intestinal disturbance etc.
2	Turbidity	5NTU(WHO)	Aesthetic problems and indication of organic/inorganic matter presence that may cause different health problems.
3	Arsenic	10ppb(WHO)	Adverse effects on CNS, Gastrointestinal, Respiratory tract, Skin muscular weakness, Loss of appetite and nausea
4	Fluoride	1.5ppm(WHO)	Dental diseases, skeletal and Crippling fluorosis
5	Potassium	12ppm(WHO)	Balance of sodium and potassium is necessary for normal function.
6	Sodium	200ppm(WHO)	Vomiting, Muscular twitching, Rigidity, Hypertension
7	TDS	1000ppm(WHO)	Health effects depend upon anions and cations.
8	Iron	0.3ppm(WHO)	Haemochromatosis
9	Nitrate as N	10ppm(WHO)	Blue baby syndrome, bladder cancer, goiter, birth defects and diabetes

3. Results and Discussion

On the basis of water analysis carried out, following contaminants found to be in higher limits than permissible by respective standards; TDS, (Total Dissolved Solids) Nitrates,

Arsenic, Fluoride, Iron, Microbial Contamination (E-Coli, Total Coliform). Analysis of the water samples collected under this study showed that the major contaminant found is microbiology. Results of the study are discussed province wise as follows;

3.1. Water Quality Status in Punjab

Indispensable role of water depends upon its quality. Under the project conducted by PCRWR, 12 districts of Punjab i.e. Islamabad, Bahawalpur, Faisalabad, Gujranwala, Gujrat, Kasur, Lahore, Multan, Rawalpindi, Sargodha, Sheikhupura and Sialkot were monitored for water quality assessment. A brief overview of water quality situation prevailing in these areas is discussed below. A total of 190 samples were collected from these districts, detail of unfit samples is given in table below.

Table-3: Water quality status in Punjab Province

Sr. #	District / Parameters analyzed	Total	TDS	Turbi-dity	K	Na	As	F	Fe	NO_3	Micro-biology
			No. of samples found unfit								
1	Islamabad	27	0	0	0	0	0	0	1	0	20
2	Bahawalpur	25	4	8	1	3	22	1	17	0	15
3	Faisalabad	13	6	0	5	7	0	2	4	0	6
4	Gujranwala	14	1	0	0	0	9	0	0	1	9
5	Gujrat	9	0	2	0	0	0	0	1	0	5
6	Kasur	10	4	0	1	5	10	2	3	1	10
7	Lahore	16	0	0	0	0	16	0	9	0	8
8	Multan	16	0	3	0	0	15	0	7	0	9
9	Rawalpindi	15	1	0	0	0	0	0	0	7	8
10	Sargodha	24	16	1	7	13	3	1	0	13	20
11	Sheikhupura	11	3	0	1	3	8	0	0	1	5
12	Sialkot	10	0	0	0	0	2	0	0	0	7

Microbiological and Arsenic are among the major contaminants found in 12 districts of Punjab. Atleast 45% of the samples collected from these districts were found to be contaminated by microbes. In district Kasur 100% of collected samples found microbiologically contaminated and unfit for drinking purpose. Very severe Arsenic contamination is found in districts Bahawalpur, Gujranwala, Kasur, Lahore, Multan and Sheikhupura where 88%, 64%, 100%, 100%, 94% and 73% of water samples were found to be contaminated by Arsenic, hence posing very high risk to the health of the population drinking that water. Figure-1 and Figure-2 presents the details of the

microbiological and Arsenic contamination in the 12 districts under monitoring of the Punjab.

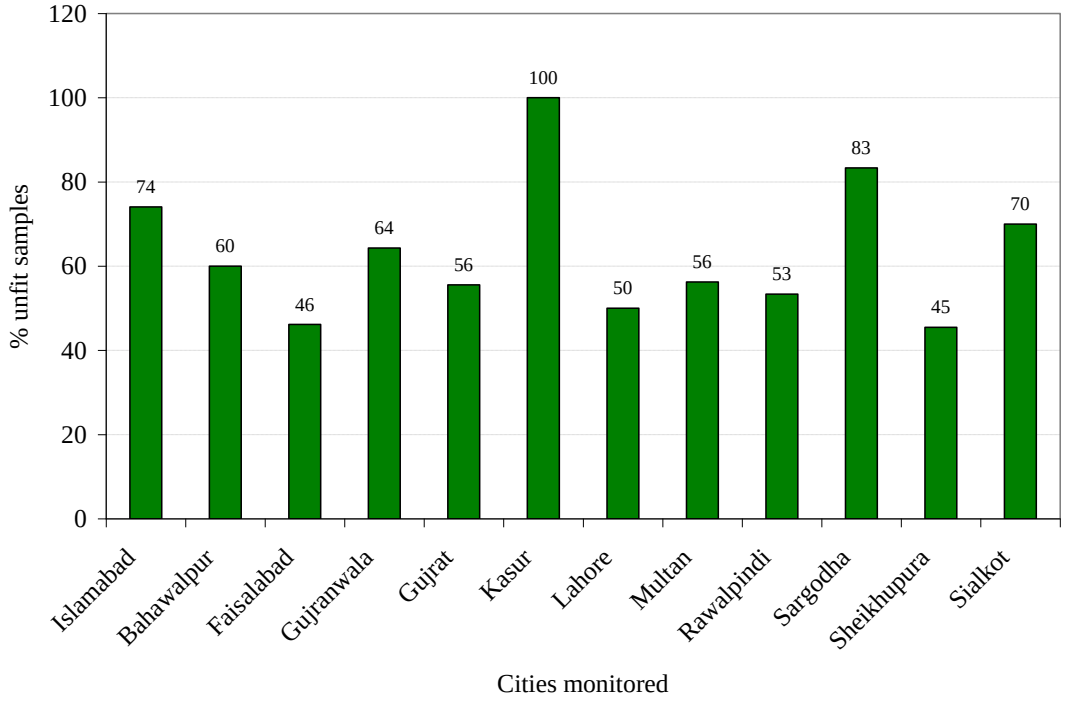

Figure-1: Microbiological contamination in 12 districts of Punjab

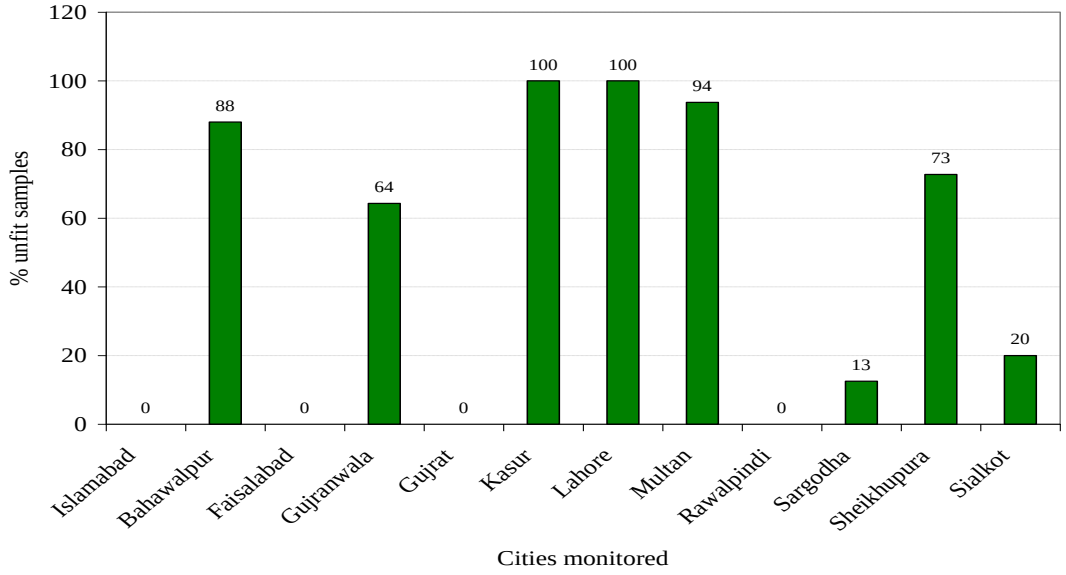

Figure-2: Arsenic contamination in 12 districts of Punjab

In the districts of Faisalabad, Kasur, Sheikhupura and Sargodha, the water samples were found to be contaminated by the higher presence than permissible limits of Total dissolved solids and in particular Sodium, while in districts of Rawalpindi and Sargodha, 47% and 54% water samples respectively were contaminated by the higher presence of Nitrates (NO_3) and eventually declared unfit for human consumption.

3.2. Water Quality Status in KPK

4 cities of the province Khyber Pakhtoonkhaw were monitored for the water quality under present study. Detail of all the water samples collected and found unfit for different physical, chemical and biological parameters are given in Table-4.

Table-4: Water quality status in KPK Province

Sr. #	District / Parameters analyzed	Total	TDS	Turbidity	K	Na	As	F	Fe	NO_3	Micro-biology
			Number of samples found unfit								
13	Abbotabad	11	0	1	0	0	0	0	0	1	6
14	Mangora	10	0	0	0	0	0	0	0	2	7
15	Mardan	12	0	0	0	0	0	0	8	1	10
16	Peshawer	13	1	0	0	0	0	0	5	0	8

Water quality analysis of the samples collected from four cities of the KPK province shows that atleast 55% of water samples from these cities are microbiologically contaminated, while in Mardan 83% of all samples found unfit. Second major contamination found in these cities is Iron. 67% and 38% of water samples from Mardan and Peshawar cities respectively were found contaminated by iron.

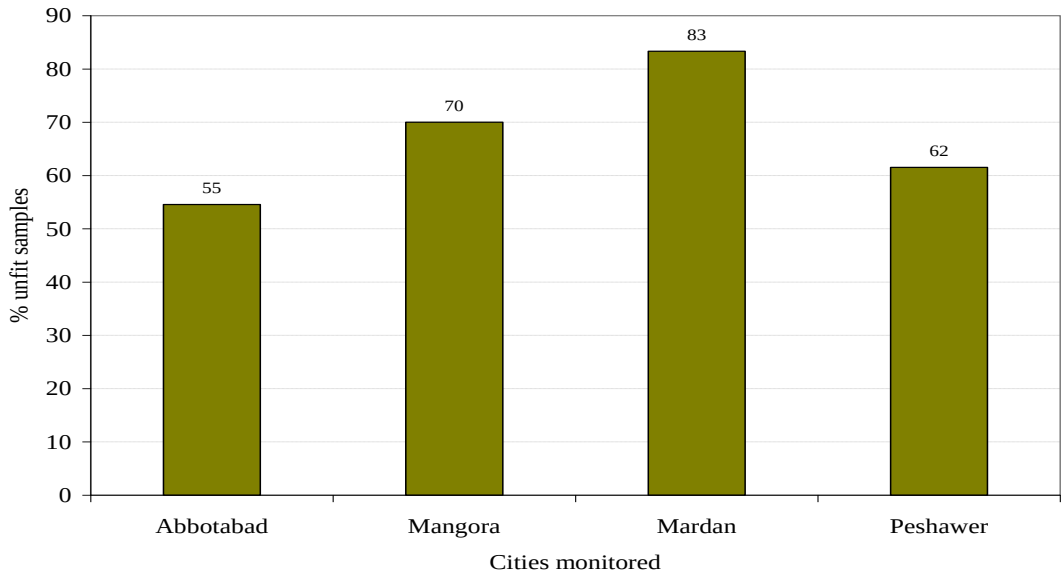

Figure-3: Microbiological contamination in 4 districts of KPK

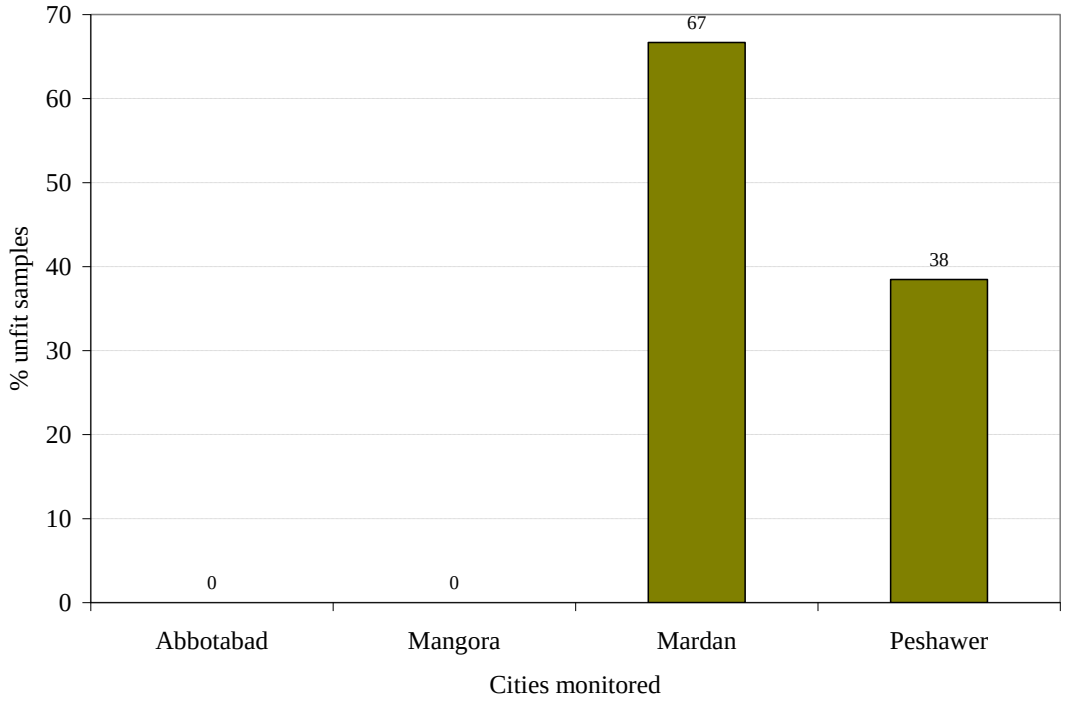

Figure-4: Iron contamination in 4 districts of KPK

3.3. Water Quality Status in Balochistan

The water quality was monitored in Balochistan province under this study in the cities of Khuzdar, Loralai, Quetta and Ziarat. Water samples analyzed found to be contaminated by microbes in all cities; the best quality in any of four cities was even contaminated upto 68%. Other parameter which strongly affected the water quality and made water unsafe for drinking purposes is Nitrate. 50% of the water samples from Ziarat found to be unsafe due to higher presence of Nitrates. The overall drinking water quality information is summarized in Figure-1 and Figure-2 presents the details of the microbiological and Nitrate contamination in 4 districts under water quality monitoring of Balochistan.

Table-5: Water quality status in Balochistan Province

Sr. #	District / Parameters analyzed	Total	TDS	Turbidity	K	Na	As	F	Fe	NO_3	Micro-biology
			No. of samples found unfit								
17	Khuzdar	11	0	0	0	0	0	0	0	2	10
18	Loralai	11	1	1	0	0	0	1	0	1	10
19	Quetta	34	3	3	0	2	0	8	9	8	23
20	Ziarat	10	0	1	0	0	0	0	2	5	10

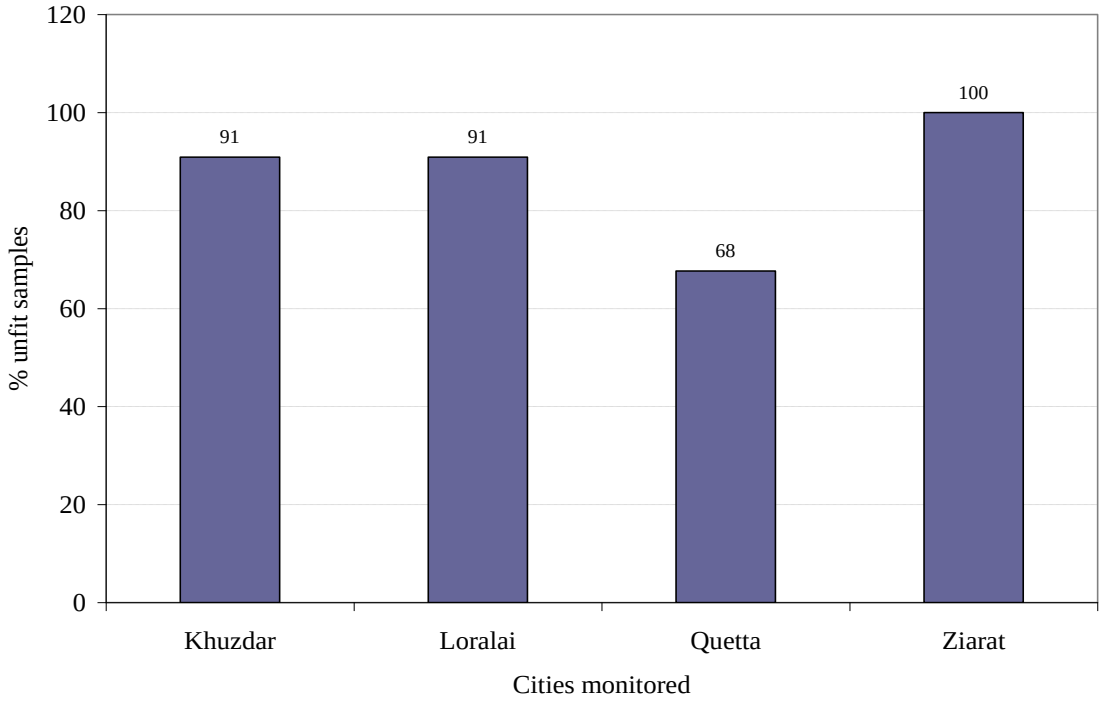

Figure-5: Microbiological contamination in 4 districts of Balochistan

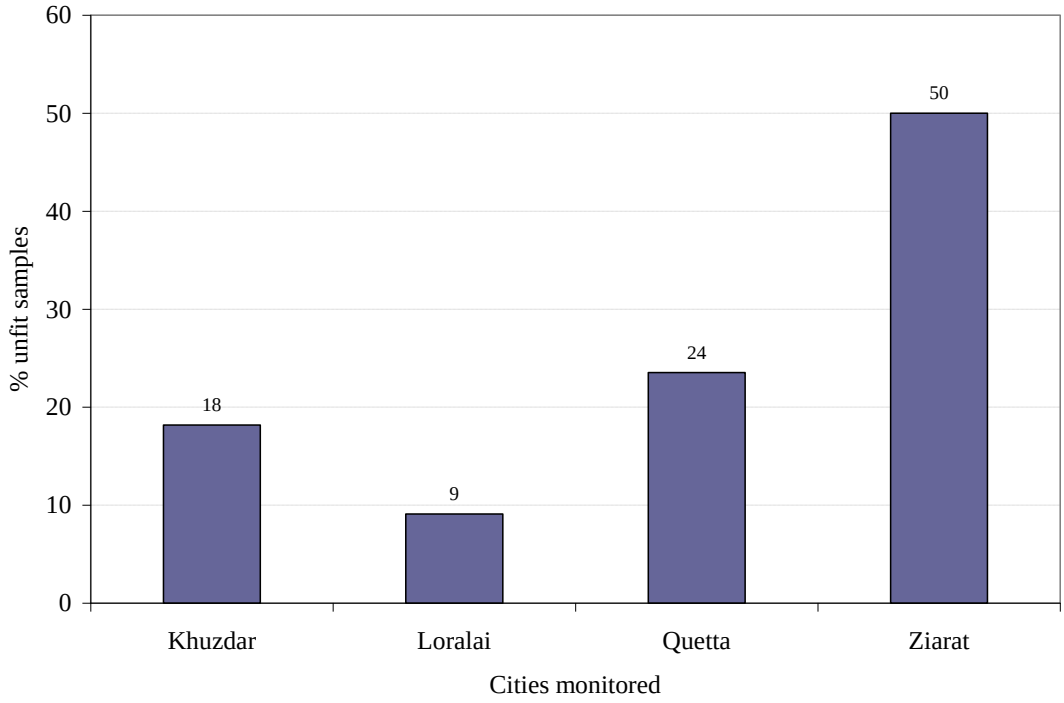

Figure-6: Nitrate contamination in 4 districts of Balochistan

3.4. Water Quality Status in Sindh

The water quality situation of the Sindh province is not much different to that of other provinces, as the percentage of unsafe water sources were in the range of 67%-93%. All these samples were contaminated by microbes. Water samples were collected and analysed in the cities of Hyderabad, Karachi and Sukkur. Overall picture of the water quality in these three districts is presented in the Table-6. Second parameter which influenced the water quality is Turbidity.

Table-6: Water quality status in Sindh Province

Sr. #	District / Parameters analyzed	Total	TDS	Turbidity	K	Na	As	F	Fe	NO_3	Micro-biology
			No. of samples found unfit								
21	Hyderabad	15	0	14	0	0	0	0	7	0	14
22	Karachi	28	1	0	1	2	0	1	5	3	24
23	Sukkar	12	2	6	1	1	1	1	0	3	8

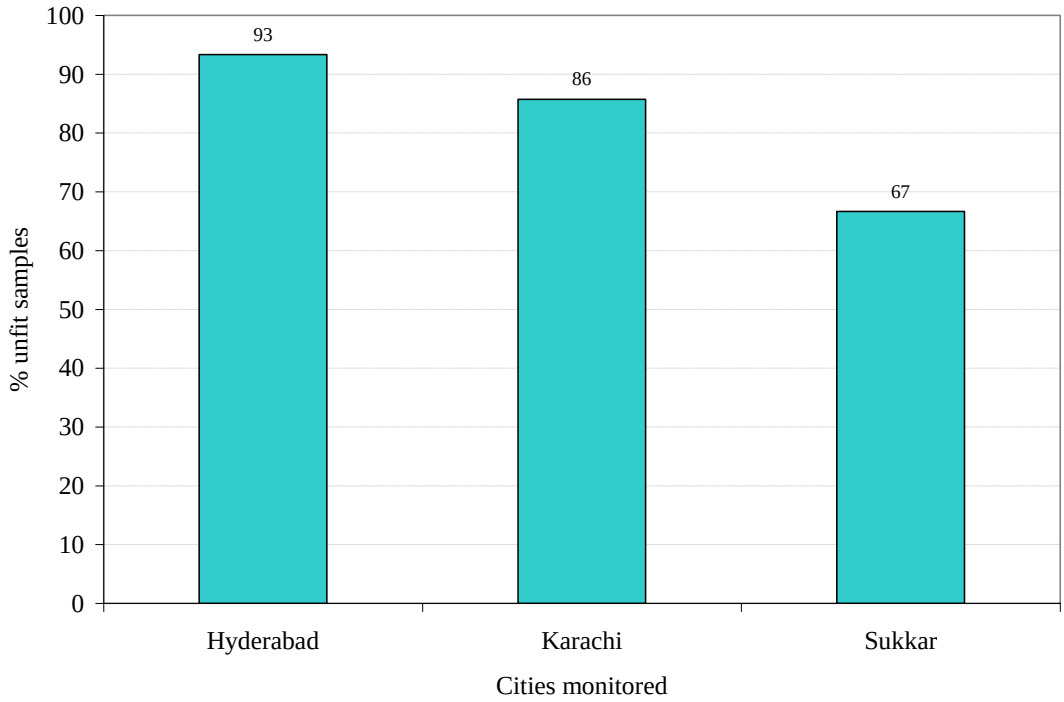

Figure-7: Microbiological contamination in 3 districts of Sindh

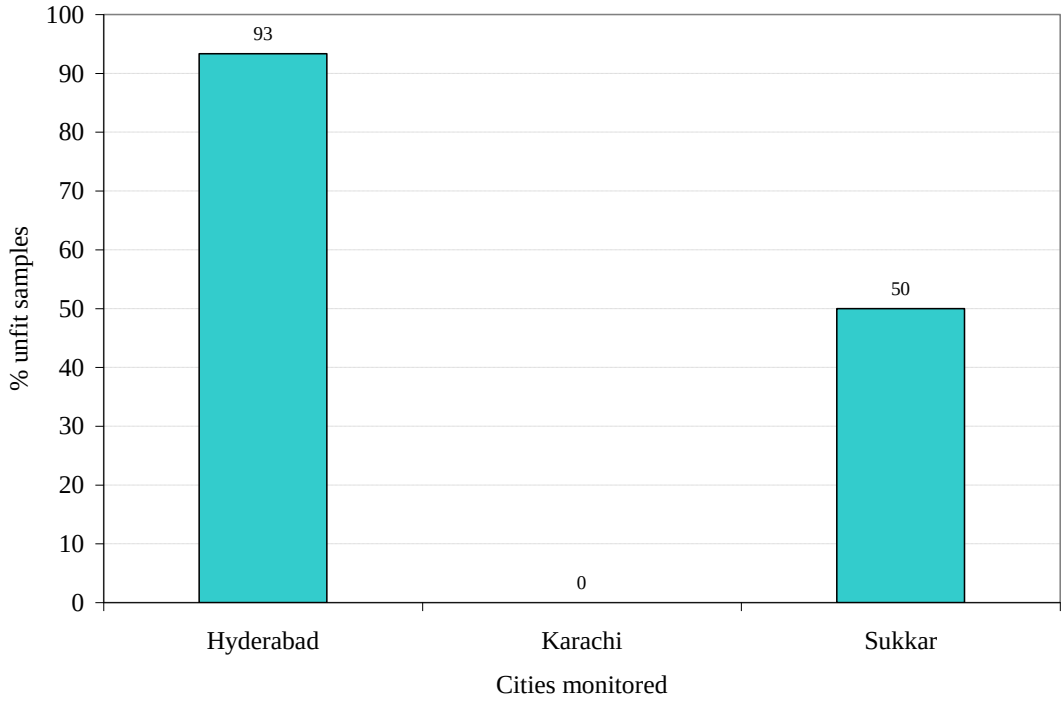

Figure-8: Turbidity contamination in 3 districts of Sindh

4. Conclusions & Recommendations

- Majority of the samples collected and analysed found to be unfit for drinking purpose in all four provinces without any exception.
- Microbiological contamination in more than half of the water samples from the 21 cities under scanning is reason for unsafe water.
- Arsenic found to be very high in the water samples collected from all major cities of Punjab, mainly due to presence of industries, which are releasing toxic materials to the effluent and finally mixed with ground water.
- Iron concentration was found to be very high in districts of Mardan and Peshawar.
- High turbidity values were obtained of the collected samples from Hyderabad and Sukkur.
- Water supply agencies including in the surveyed cities, all over the country, must ensure that the water being supplied to the user is free of bacterial contamination.
- No water supply scheme should be approved unless detailed investigations of the quality, quantity and sustainability has been carried out.

- Alternate source should be identified in areas where the quality of existing source of water supply is contaminated.

5. References

1. Dawn, 1989, G. O. Punjab, 1989. Health management Information System, Annual Report, Department of Health.

2. Kosek, M., Bern, C., Guerrant, R.L., 2003. The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. Bulletin of the World Health Organization, 81, pp. 197-204.

3. Tahir, M.A et al. (1994) survey of drinking water Quality in Rural Areas of Rawalpindi District, Pakistan Council of Research in Water Resources, Islamabad, Pakistan.

4. The Pakistan National Conservation Strategy, 1992, chapter-2, para-2.2, page-36.

5. Water quality status third report, 2003 Chapter-1, page 3, Prepared by Pakistan Council of Research in Water Resources (PCRWR).

6. WHO1972-73 Technical Report Series No.505, 532. World Health Organization, Geneva.