

EXECUTIVE SUMMARY

The National Water Quality Monitoring Programme (NWQMP) was initiated by Pakistan Council of Research in Water Resources (PCRWR) in 2002. It was the premier project of the year which generated the first detailed water quality profile of 23 major cities of the country. The NWQMP continued for five years (2002-2006). This report is the final and fifth technical report of 2005-06 and presents the results of the final phase of the monitoring program. During this phase, 357 water samples from 364 selected water sources were collected, adopting the uniform sampling criteria and analyzed for 79 physico-chemical parameters, including trace, ultra trace elements and bacterial indicators. The analytical findings were compared to World Health Organization (WHO) guidelines and Pakistan Standards Quality Control Authority (PSQCA) standards for drinking water.

In Federal Capital Islamabad, only 7 sources out of 27 (26%) were found safe and the rest of the 74% were unsafe due to bacteriological contamination. In Bahawalpur city, all sources (25) were found unsafe due to bacteriological as well as chemical contamination i.e. arsenic (88%), turbidity (32%), iron (68%), sulfate (20%), sodium (12%), lead (8%) and TDS (16%). In Faisalabad, 3 sources out of 13 were found safe and the remaining 10 sources were found unsafe due to bacteriological contamination, high sulphate and TDS (46%), iron (31%) hardness (23%), sodium (54%), potassium, chlorides (38%) and fluoride (15%). In Gujranwala, all 14 sources were found unsafe due to bacteriological as well as the chemical contamination of arsenic, nitrate and TDS (7%), while only one (1) source was supplying safe drinking water. In Gujrat, 4 sources out of 9 were found unsafe due to bacteriological contamination (56%), turbidity (22%) and iron (11%). In Kasur, all sources (10) were unsafe due to bacteriological contamination and high TDS (40%), arsenic (100%), sodium (50%), potassium (10%), fluoride, sulfate (20%) and nitrate (10%). Lahore, the second largest city of Pakistan has shown an alarming situation of drinking water contamination as all 16 of its sources were supplying unsafe water due to bacteriological (50%) and arsenic (100%) contamination. A similar situation was found in Multan, where all 16 sources were found unsafe due to bacteriological contamination (56%) and arsenic (94%) contamination. In Rawalpindi, out of 15 sources, 11 were found contaminated by bacteriological contamination (53%) and TDS (7%) and nitrate (47%). In Sargodha city, only one source, out of a total of 24 locations, was found safe for drinking purpose and the major causes of contamination were bacteriological (83%), arsenic (13%), sodium (54%), potassium (29%), chloride (46%), sulfate (38%), TDS (67%), nitrate (54%) and fluoride (4%). A similar situation was prevailing in Sheikhpura, where all 11 sources were supplying unsafe water to the public mainly due to the presence of bacteriological contamination (45%), excessive levels of potassium, sulphate and nitrate (9%), arsenic (73%), sodium and TDS (27%). In Sialkot, only three sources out of 10 were supplying safe water and the rest have shown excessive levels of bacteriological (70%) and arsenic (20%) contaminants.

In NWFP, out of a total 11 sources, 3 sources of Abbottabad, were supplying safe water and rest were found polluted with bacterial (55%) contamination, excessive levels of nitrate and turbidity in 9% samples. In Mangora, 80% samples were found unfit due to the prevalence of fecal contamination (70%), excessive levels of nitrate (20%) and lead (10%), whereas the remaining 20% were found safe. In Mardan, out of 12 sources, 11 samples were found unsafe due to bacteriological contamination (83%),

high iron (67%) and nitrate (8%) concentration. Peshawar, the capital of NWFP, has indicated 77% of the unsafe water sources due to bacteriological contamination (62%), iron (38%) and TDS (8%). In Balochistan Province, 66 water sources of 4 cities were monitored. In Khuzdar, out of 11 sources, 10 were found to be unsafe due to bacteriological contamination (91%), fecal contamination by *E.Coli* (82%) and excessive nitrate (18%). In Loralai, 91% of the 11 water sources were found unsafe because of bacteriological contamination (91%), and nitrate, fluoride, TDS, hardness and turbidity more than permissible limits. In Quetta, the capital of Balochistan, 76% samples were unsafe, mainly due to bacteriological contaminants (68%), excessive iron (26%), fluoride and nitrate (24%). Only 8 sources out of 34 were supplying safe drinking water in Quetta. The worst water quality situation was found in Ziarat, where all the 10 selected sources were contaminated, with bacteriological contamination contributed by fecal pollutants (100%) and excessive levels of nitrate (50%) and iron (20%).

In Sindh Province, all the 15 sources monitored in Hyderabad city were found unfit mainly due to bacteriological contamination (93%), excessive levels of iron (47%) and turbidity (93%). Karachi, the largest metropolitan city and capital of Sindh province revealed 93% unsafe water sources due to the presence of bacteriological contamination (86%), TDS and fluoride (4%), sodium, chlorides, sulphate (7%), nitrate (11%) and iron (18%). Only 2 out of a total of 28 were found safe. In Sukkur, 11 out of 12 sources were unfit because of bacteriological contamination (67%) and turbidity (50%), hardness, chlorides, sodium, potassium, arsenic and fluoride (8%), nitrate (25%), sulphate and TDS (17%).

Twenty two water samples including 6 dams, 9 rivers, 2 canals, 4 lakes and 1 drain; Left Bank Outfall Drain (LBOD), Right Bank Outfall Drain (RBOD), Sukkur) from 23 selected surface water bodies were also collected and analyzed for 28 water quality parameters. All samples (22) were found microbiologically contaminated. Only 3 samples (14%) showed high TDS values.

Detailed data analysis has identified 4 major water quality tribulations in drinking water sources of Pakistan i.e. bacteriological (68%), arsenic (24%), nitrate (13%) and fluoride (5%). On an overall basis, out of a total of 357 only 45 water sources (13%) were found "Safe" and the remaining 312 (87%) were "Unsafe" for drinking purpose. The bacterial contamination level (2002-2006) was in the range of 40-74% for Islamabad, 38-79% for Faisalabad, 52-76% for Bahawalpur, 29-71% for Gujranwala, 56-100% for Gujrat, 40-50% for Kasur, 37-63% for Lahore, 31-87% for Multan, 53-87% for Rawalpindi, 27-55% for Sheikhpura, 40-70% for Sialkot, 75-92% for Sargodha, 62-100% for Khuzdar, 73-100% for Loralai, 48-68% for Quetta, 100% for Ziarat, 40-70% for Mangora, 75-83% for Mardan, 31-77% for Peshawar, 55-73% for Abbottabad, 73-100% for Hyderabad, 61-100% for Karachi and 67-83% for Sukkur during 2002-06. The outcome of all the five phases (2002-06) of NWQMP has led to the realization that the Federal, Provincial and Local Governments need to take immediate initiatives for the provision of safe drinking water to the public in order to prevent the onslaught of water born diseases. Advocacy efforts for the awareness and education of the general public, regarding the water quality testing and treatment are required.

RESULTS AND DISCUSSION

This chapter presents the results of the fifth and final phase of the National Water Quality Monitoring Programme which was completed in 2005-2006. This report covers the water quality analysis of 23 major cities, 8 rivers, 6 dams, 4 lakes, 2 canals, 2 drains and 1 reservoir. The 11 cities of the Punjab province covered this year were Bahawalpur, Faisalabad, Gujranwala, Gujrat, Kasur, Lahore, Multan, Rawalpindi, Sargodha, Sheikhpura and Sialkot. From NWFP, Abbottabad, Mangora, Mardan and Peshawar were monitored. While Khuzdar, Loralai, Quetta and Ziarat were monitored from the Balochistan. From the Sindh province Hyderabad, Karachi and Sukkur were included in the monitoring program. The locations for the sample collection in all cities were selected, keeping in view the source from where most of the population consumed water for drinking purpose. In total 364 permanent locations from 23 cities were selected for the collection of the water samples. However, 7 water sources in the Balochistan province (2 in Loralai, 4 in Quetta and 1 in Ziarat) were not functioning and therefore, water samples could not be taken from these sites. Consequently, 357 water samples were taken for laboratory analysis with the following distribution:

Islamabad 27
Punjab 163
NWFP 46
Balochistan 66
Sindh 55

Total 357

The area wise distribution of water sources is as under:

- i. **Islamabad:** Tubewell (19), W.Supply Schemes (2), Cistern (1), Reservoir (1), Bore (1), Tap (3) **(Total, 27)**
- ii. **Punjab:** Tubewell (90), W.Supply Schemes (8), Bore (9), Tap (4), Hand Pump (37), Injection Pump (13), Donkey Pump (1), Well (1) **(Total, 163)**
- iii. **NWFP:** Tubewell (41), W.Supply Schemes (2), Hand Pump (1) and Bore (2) **(Total:46)**
 - ◆ **iv. Balochistan:** Tubewell (31), W.Supply Schemes (13), Cistern (1), Tap (4), Well (5), Karez (3), Spring (5), Windmill (1), Dam (1), Hand Pump (2) **(Total: 66)**
 - ◆ **v. Sindh:** W.Supply Schemes (7), Tap (41), Hand Pump (7) **(Total:55)**

The water quality parameters for which the samples were analyzed are mainly divided into the following four categories:

- i. **Physical and Aesthetic:** pH, Electrical Conductivity (EC), Turbidity, Colour, Taste, Odour.
- ii. **Major Inorganic Constituents:** Alkalinity (Alk), Bicarbonate (HCO_3), Carbonate (CO_3),

Calcium (Ca), Magnesium (Mg), Hardness, Sodium (Na), Potassium (K), Chloride (Cl), Sulphate (SO₄), Nitrate (NO₃), Phosphate (PO₄), Total Dissolved Solids (TDS).

iii. **Trace and Ultra Trace Elements:** Silver (Ag), Aluminium (Al), Arsenic (As), Beryllium (Be), Bismuth (Bi), Cadmium (Cd), Cerium (Ce), Cobalt (Co), Chromium (Cr), Cesium (Cs), Copper (Cu), Dysprosium (Dy), Erbium (Er), Europium (Eu), Fluoride (F), Iron (Fe), Gallium (Ga), Gadolinium (Gd), Germanium (Ge), Hafnium (Hf), Mercury (Hg), Holmium (Ho), Indium (In), Iridium (Ir), Lanthanum (La), Lithium (Li), Lutetium (Lu), Manganese (Mn), Molybdenum (Mo), Niobium (Nb), Neodymium (Nd), Nickel (Ni), Lead (Pb), Palladium (Pd), Praseodymium (Pr), Platinum (Pt), Rubidium (Rb), Rhenium (Re), Rhodium (Rh), Ruthenium (Ru), Scandium (Sc), Selenium (Se), Samarium (Sm), Tin (Sn), Strontium (Sr), Tantalum (Ta), Terbium (Tb), Tellurium (Te), Thorium (Th), Titanium (Ti), Thallium (Tl), Thulium (Tm), Vanadium (V), Tungsten (W), Yttrium (Y), Ytterbium (Yb), Zinc (Zn), Zirconium (Zr).

iv. **Bacteriological Parameters:** Coliform and Escherichia Coli (*E.Coli*).

All the analyzed parameters were compared with the WHO guidelines and the PSQCA Standards in order to evaluate whether the samples were “Safe” or “Unsafe” for drinking purposes.

4.1 FEDERAL AREA-Islamabad

From the city of Islamabad, 27 locations were selected for the sample collection. Out of these 27 locations, 07 water sources were found safe for drinking while the rest of the water sources were found unfit for human consumption, either due to chemical or microbiological contamination. The analysis revealed that 74% of the samples were found to be contaminated with Coliforms and 41% were polluted with *E. Coli*. Furthermore, 59% of the samples were identified as having an excessive presence of Ca than the permissible limits allowed but were considered safe, as a slightly excessive amount of calcium is not hazardous to health. One sample had a slightly excessive Fe concentration than the WHO guidelines (*Annexure-01*). The results of the monitoring carried out in Islamabad in 2005-06 are given in Table-4.1.

Table 4.1 Summary of Water Quality Analysis of Islamabad (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Ca	(mg/l)	27	16	59
2	Coliform	(MPN/100 ml)	27	20	74
3	E.Coli	(MPN/100 ml)	27	11	41

The microbiological contamination in Islamabad could be due to an inadequate water decontamination and disinfection practice, being followed by leakages within the distribution network due to an intermittent water supply etc. The CDA responsible authorities should improve the chlorination practices along with the water distribution infrastructure (especially to control leakage) on a priority basis in an effort to supply safe drinking water to the residents of the city.

4.2 PUNJAB PROVINCE

4.2.1 Bahawalpur

From Bahawalpur City, 25 water sources (12 Tube Wells and 13 Hand Pumps) were monitored, keeping in view the source from where most of the population consumed water for their drinking purpose. According to the water quality data, it was revealed that all the water samples were unfit for human consumption either chemically or microbiologically. Out of the 25 samples, 60% of the samples were found to be contaminated with coliforms; 88% possessing excess Arsenic (As) than permissible limits. Most of the samples had more than 50 ppb which is 5 times more than the WHO set guideline for arsenic in drinking water. Samples with a high Total Dissolved Solids (TDS) were 16%, where as 32% of the samples possessed excessive levels of turbidity, and 60% of the samples had a higher concentration of calcium (Ca). The tubewell of Commercial Area, Satellite Town was pumping water containing more soluble ions of Ca (200 mg/l), which may be due to the presence of underground calcareous mineral rocks. Chloride, Fluoride, Potassium and Hardness were observed beyond the permissible limits in 4% of the water samples. 12% and 20% water samples had excessive sodium and sulphate respectively. The results of the samples are presented at *Annexure-2*. Information regarding the %age of contaminated samples beyond the permissible limits of different water quality parameters are presented in Table-4.2.

Table 4.2 Results of Water Quality Analysis of Bahawalpur (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Turbidity	(NTU)	25	8	32
2	Ca	(mg/l)	25	15	60
3	Hardness	(mg/l)	25	1	4
4	Na	(mg/l)	25	3	12
5	K	(mg/l)	25	1	4
6	Lead (Pb)	(mg/l)	25	2	8
7	Cl	(mg/l)	25	1	4
8	SO ₄	(mg/l)	25	5	20
9	TDS	(mg/l)	25	4	16
10	As	(ppb)	25	22	88
11	Fe	(mg/l)	25	17	68
12	F	(mg/l))	25	1	4
13	Coliforms	(MPN/100 ml)	25	15	60
14	E.Coli	(MPN/100 ml)	25	2	8

4.2.2 Faisalabad

Faisalabad is a main big industrial city of Pakistan, where the quality of water is deteriorating with the passage of time. Hepatitis-A and gastroenteritis are common diseases in the city, as a result of the unavailability of safe drinking water. The TDS is increasing in most of the sources due to the dumping of industrial waste in water sources without treatment. A water quality crisis occurred in Faisalabad in which more than 20 persons died as a result of drinking contaminated water in the year 2006. An emergency was imposed in the city hospitals, as more than 20 thousand patients of gastroenteritis were hospitalized. The major cause of the drinking water contamination were old and leaky, rusted water pipes. For water quality monitoring in Faisalabad, 13 locations were selected covering the major water sources of the city. The overall supply of drinking water was found unsatisfactory as out of the 13 sources, only three sources were supplying safe drinking water. The water quality analysis revealed that 46% of the water samples were found polluted with Coliforms & *E.Coli*, the same %age of sources were identified having excessive concentrations of SO₄ & TDS. About 54% and 23% of the samples were found with excessive sodium and hardness

respectively. Whereas 38% samples were identified with a higher level of K and Cl than permissible limits allowed, another 15% sources had more F and Cd than the WHO guideline values permitted for drinking water. Thirty one % of the samples were identified as having higher Ca and Fe values. The details of the analysis are given at *Annexure-3*. All the information regarding %age samples beyond the permissible limits of different water quality parameters is given in Table 4.3.

Table 4.3 Results of Water Quality Analysis of Faisalabad (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Ca	(mg/l)	13	4	31
2	Hardness	(mg/l)	13	3	23
3	Na	(mg/l)	13	7	54
4	K	(mg/l)	13	5	38
5	Cl	(mg/l)	13	5	38
6	SO ₄	(mg/l)	13	6	46
7	TDS	(mg/l)	13	6	46
8	F	(mg/l)	13	2	15
9	Fe	(mg/l)	13	4	31
10	Cd	(ppb)	13	2	15
11	Coliforms	(MPN/100 ml)	13	6	46
12	E.coli	(MPN/100 ml)	13	6	46

4.2.3. Gujranwala

In total, 14 samples were collected from the Gujranwala city covering all the possible drinking water sources. Out of the 14 sources no one was supplying safe drinking water, except one which had a slightly higher level of Ca. The results of the analysis identified that 64% of the water

samples were found to be contaminated due to the presence of coliforms and E.Coli. Whereas 64% of the water samples were found to be contaminated with Arsenic (As) and 7% of the samples had excessive TDS and NO₃. Details of the analysis are given in Annexure-4. All the information regarding the %age of the contaminated samples beyond the permissible limits of different water quality parameters are given in Table-4.4.

Table 4.4 Results of Water Quality Analysis of Gujranwala (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Ca	(mg/l)	14	5	36
2	TDS	(mg/l)	14	1	7
3	NO ₃	(mg/l)	14	1	7
4	As	(ppb)	14	9	64
5	TI	(ppb)	14	4	29
6	Coliforms	(MPN/100 ml)	14	9	64
7	E.coli	(MPN/100 ml)	14	5	36

4.2.4 Gujrat

From the Gujrat city area, 9 water samples were collected from water sources according to the sampling design. The water sources included; Tubewells (7), a Hand Pump (1) and a Donkey Pump (1). Out of the 9 water sources, four were supplying safe drinking water to the community while the rest were providing the citizens contaminated water. The water quality analysis results revealed that 56% of the water samples were polluted with Coliforms and *E. coli.*, 22% of the samples were found turbid and 01 sample (11%) had a higher concentration of Fe and Manganese (Mn) (*Annexure-05*). All the details regarding the %age of the contaminated samples are given in Table 4.5.

Table 4.5 Results of Water Quality Analysis of Gujrat (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	Turbidity	(NTU)	9	2	22
2	Fe	(mg/l)	9	1	11
3	Mn	(ppb)	9	1	11
4	Coliforms	(MPN/100 ml)	9	5	56
5	E.coli	(MPN/100 ml)	9	5	56

4.2.5 Kasur

Kasur is an industrial city and is known for its tanneries in Pakistan. From this city, a total of 10 sources from predetermined locations were selected to monitor the water quality. The sources were selected from areas where most of the population obtains their drinking water. It was found that all the 10 sources were supplying contaminated drinking water. In each case, one or more contaminants were present in the drinking water. The analysis of water quality data showed that 40% of the samples were polluted due to the presence of Coliforms and *E.Coli*. All water samples were identified as having an excessive As concentration when compared with the WHO guidelines. Similarly 20 % of the samples had unacceptable levels of SO₄ and F, whereas 30% and 10% of the samples had exceeded the WHO Guidelines for Fe & NO₃. Excessive potassium was found in 10% and sodium in 50% of the samples collected from Kasur. Results regarding the %age of the contaminated samples because of different water quality parameters are given in Table 4.6.

Table 4.6 Results of Water Quality Analysis of Kasur (2005-06)

Sr. No.	Water Quality Parameter	Unit	Total No. of Samples Analyzed	Number of Contaminated Samples	%age of Contaminated Samples
1	K	(mg/l)	10	1	10
2	Na	(mg/l)	10	5	50
3	SO ₄	(mg/l)	10	2	20
4	NO ₃	(mg/l)	10	1	10
5	TDS	(mg/l)	10	4	40
6	As	(ppb)	10	10	100
7	Fe	(mg/l)	10	3	30
8	F	(mg/l)	10	2	20
9	Coliforms	(MPN/100 ml)	10	4	40
10	E.coli	(MPN/100 ml)	10	4	40

4.2.6 Lahore

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