Policy Brief # **60**

Comparative Assessment of Pakistan National Drinking Water Quality Standards with Selected Asian Countries and World Health Organization

Dr Mahmood A. Khwaja and Anum Aslam

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Mailing Address: PO Box 2342, Islamabad, Pakistan.

Telephone ++ (92-51) 2278134, 2278136, 2277146, 2270674-76

Email Address: *khwaja@sdpi.org*

Fax ++(92-51) 2278135, URL: www.sdpi.org

Table of Contents

1. Introduction

World Health Organization defines "safe-drinking water" as the water that does not represent any significant risk to health over the lifetime of its consumption, including different sensitivities that may occur between life stages. Being the most drinking fluid, water is believed to be the major source of transmitting diseases (Ullah et al. 2014). According to World Health Organization (WHO), 80% of all human diseases are reported to occur due to the biological contamination of water in the developing countries (Sulehria et al. 2013). Drinking water quality has been debated throughout the world due to its increasing demand for human consumption as well as its detrimental effects of increased urbanization and industrialization. Direct discharge of domestic waste, industrial effluents, agricultural run-offs, leakages from septic tanks, and poor management of farm wastes are considered the main water pollution sources (Nabeela et al. 2014).

In Pakistan, access to safe drinking water is one of the major public health problems, as the country is facing water quality and quantity issues, being documented in various studies. The large proportion of drinking water, almost 70%, comes from ground water aquifers within the country (Butt and Khair 2014). Bacteriological contamination, toxic metals like arsenic, iron, cadmium, nickel, pesticides and in some areas nitrates and fluorides are major threats to water quality within the country (Azizullah et al. 2011). In Pakistan, microbial contamination in drinking water has been highlighted as a major cause of illness and deaths among people, especially children who are most vulnerable (Daud et al. 2017). Intermittent water supply is common in urban areas and outbreaks of gastroenteritis and other water borne diseases have become a normal feature (Hayder et al. 2009). It has been estimated that 30% of all diseases and 40% of all deaths are occurred due to poor water quality (particularly fecal contamination) within the country. 20-40% of beds in Pakistani hospitals are occupied by patients suffering from waterborne diseases, including cholera, diarrhea, dysentery, hepatitis, typhoid, etc. (Nabeela et al. 2014). Water-linked diseases in Pakistan cause national income losses of Rs 25-28 billion annually, which is approximately 0.6-1.44 % of the country's GDP (Tahir at al., 2010).

Unfortunately, little attention is paid to drinking water quality issues within the country as the water supply agencies primarily focus on the quantity rather than the quality of drinking water. Moreover, weak institutional arrangement, lack of well-equipped laboratories, no periodic water quality monitoring and the absence of a legal framework for drinking water quality issues have aggravated the situation (Hayder et al. 2009).

In September 2009, the Federal Cabinet of Pakistan approved the National Drinking Water Policy (NDWP)to address the key issues and challenges in the provision of safe drinking water. The overall goal of the policy is to ensure safe drinking water to the entire population at an affordable cost in an equitable, efficient and sufficient manner and to ensure reduction in the incidence of mortality and morbidity caused by water borne diseases. It has been notified in the policy that the federal government would be responsible for developing special action plans for the un-served and under-served areas, brackish zones, for areas prone to natural calamities like floods, drought and earthquakes, as well as those areas where women have to walk more than 0.5 km to acquire the access to safe drinking water.

In 2004, Pakistan Council of Research in Water Resources (PCRWR) prepared a report related to water quality in Pakistan with recommendations for establishing national drinking water quality standards.

Ministry of Health, Government of Pakistan and World Health Organization (WHO) reviewed the drinking water standards implemented in Pakistan for quality control, updated the same in accordance with the drinking water quality standards of WHO and finalized (Pak-EPA 2008).

According to the 2009 National Drinking Water Policy, Pakistan's first safe drinking water act would be prepared and enacted. The policy also declared the safe drinking water as fundamental human right. Cost- effective technology will be deployed in this regard to utilize the local government resources optimally. The Ministry of Environment (presently Ministry of Climate Change), Pakistan Council of Research in Water Resources (PCRWR) and Pakistan Standards and Quality Control Authority (PSQCA) were held responsible for the dissemination of information to all stakeholders regarding the Pakistan National Standards for Drinking Water (Government of Pakistan 2009).

The drinking water quality standards (Annexure 1) were reviewed and notified in the official gazette of Pakistan on 26 November 2010 as fulfillment of the provision of the National Drinking Water Policy 2009 (The gazette of Pakistan 2010).

Presently, the draft National Water Policy, 2017, prepared by Ministry of Water Resources, which Provides "Guidelines" to the provinces to develop their water policies and strategies, is under consideration (Ghumman, 2018). Council of Common Interest (CCI), in a recent meeting, has deferred the approval of NDWP, despite agreeing the need to adapt it (Haq 2018).

Health impacts due to consumption of contaminated poor quality drinking water:

Water borne diseases are of either microbial or chemical origin. Consuming unsafe drinking water poses greater risk of water borne diseases on general public. Small children having more drive to explore and play, have closer contact with ground and little appreciation of hygiene. Hence, they are more likely to come in contact with excreta & contaminated mud, the primary sources of diarrheal diseases and intestinal parasites as well as other pathogens (Hunter et al., 2013). According to WHO, globally there are 4 billion cases of diarrhea each year and many other illnesses due to lack of access to clean water (Butt and Khair 2014). In 2006, around 4.5 million cases of diarrhea were reported in Pakistan, 14% of which were children under the age of 5 years (Nabeela et al. 2014).

Diarrhea is the second leading cause of death in children under five. Although it is a preventable and treatable disease, however, due to unsafe drinking water, lack of personal hygiene and poor sanitation as well as malnutrition, it kills around 760,000 children every year in developing and third world countries (WHO 2013). UNICEF child mortality data shows that about half of under-five deaths occur in India, Nigeria, Democratic Republic of the Congo (DRC), Pakistan, and China. Of the 783 million people worldwide without improved drinking water, there are 119 million in China; 97 million in India; 66 million in Nigeria; 36 million in DRC; and 15 million in Pakistan (UNICEF, 2013).

Like microbial contamination, chemical contamination also poses serious health risks to infants and children health, hence making them susceptible to various diseases (WHO 2011). Health risks due to some specific chemicals/chemical entities are briefly given in Annex 2.

The objective of this study is to assess the current status of Pakistan National Drinking Water Quality Standards, i.e. whether our standards are stringent or relaxed in comparison to other selected 10 Asian countries and if these are consistent with WHO drinking water quality standards. Only a few selected drinking water quality parameters of priority public health concern (Aslam 2017; Daud et al. 2017 & Shigeta 2001) have been taken into account.

2. Methodology:

Secondary data was collected through various means for the study. Existing literature on drinking water quality issues in Pakistan was explored and consulted. Various online sources were also utilized. More information was gathered through personal communication with the authorities concerned.

In the foregoing pages, a few selected drinking water quality priority parameters of public health concerns have been taken into account for assessing them comparatively in the context of Pakistan with a few other Asian countries. The selected Asian countries include: India, Sri Lanka, Nepal, China, Japan, Korea, Malaysia, Indonesia, Philippines, and Vietnam. World Health Organization (WHO) standards are also included for comparison. Details of drinking water quality standards of each selected country, with respective references/sources of information have been recently compiled and reported (Aslam 2017).

3. Results and discussion:

The selected drinking water quality parameters' guideline values in the 10 Asian countries & Pakistan along with (WHO) standards, are given in Table 1 & 2, as "Physical" and "Chemical" parameters of drinking water quality.

3.1. Drinking water quality – Physical Parameters:

The selected physical parameters are total hardness, total dissolved solids (TDS) and pH.

For total hardness, Indonesia has the lowest value and both Malaysia & Pakistan have the highest value (also higher than the WHO value) among the 11 Asian countries (Table 1). For TDS, 4 countries have value half that of WHO (1000 mg/l) while Pakistan, China, Nepal and Malaysia have the same value as described by WHO. For pH, all countries (except Japan), including Pakistan have WHO values between (6.5–8.5), as standard for drinking water quality (Table 1).

Table 1: Drinking water quality: Physical Parameters

Parameter	Standard Values For Asian Countries												
	Pakistan	**India**	**Sri lanka**	**Nepal**	**China**	**Japan**	**Korea**	**Malaysia**	**Indonesia**	**Singapore**	**Philippine**	**Vietnam**	**WHO**
Physical Parameters													
Total hardness CaCo3(mg/l)	<500	Max. 200	Max. 250	Max. 500	450	-----	------	500	170	------	Max. 300	-----	100-300

TDS (mg/l)	< 1000	Max. 500	Max. 500	Max. 1000	1000	----	-----	1000	500	-----	Max. 500	-----	< 1000
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	5.8-8.6	-----	-----	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5

Aslam, 2016

3.2. Drinking water quality – Chemical Parameters

The selected chemical parameters for drinking water quality are given in Tables 2A & 2B.

For better clarity, Arsenic (As), cadmium (Cd), chromium (Cr), chloride (Cl) and copper (Cu) are included in Table 2A and the rest of six chemical parameters of priority concern in Table 2B.

For arsenic (As), five Asian countries follow WHO standard (0.01 mg/l), whereas other countries, including Pakistan have value five times higher (0.05 mg/l) than the WHO value. Indonesia has the highest value (0.1 mg/l) for cadmium (Cd) among all the studied Asian countries (Table 2A). Five Asian countries follow WHO value (0.003 mg/l), whereas in Pakistan, for cadmium (Cd) the value is much higher (0.01 mg/l) than WHO and is same for Japan, Singapore and Vietnam. WHO value of 0.05 mg/l for chromium, is followed by all the 12 Asian countries, including Pakistan (Table 2A). For chloride (Cl) Japan has the minimum value (200 mg/l). Pakistan and the rest of 10 Asian countries water quality standard value for chloride (Cl) is same as that of WHO (250mg/l). For copper (Cu), India has the lowest value (0.05 mg/l) among all the studied Asian countries which is much lower than WHO value (2.0 mg/l). Pakistan is the only country which follows WHO value for copper. Most of the Asian countries have water quality standard (1.0 mg/l) for copper half that of WHO (Table 2A).

Table 2A: Drinking water quality: Chemical Parameters

Parameter	**Standard Values For Asian Countries**												
	Pakistan	**India**	**Sri lanka**	**Nepal**	**China**	**Japan**	**Korea**	**Malaysia**	**Indonesia**	**Singapore**	**Philippine**	**Vietnam**	**WHO**
Chemical Parameters													
As	≤500	Max. 0.01	0.01	Max. 0.05	0.01	0.01	0.05	0.01	0.05	0.05	Max. 0.05	0.05	0.01
Cd	0.01	Max. 0.003	0.003	Max. 0.003	0.005	0.01	0.005	0.003	0.1	0.01	Max. 0.003	0.01	0.003

Cr	≤500	Max. 0.05	0.05	Max. 0.05	0.05	0.05	0.05	0.05	----	0.05	Max. 0.05	0.05	0.05
Cl	<250	Max. 250	250	Max. 250	250	200	-----	250	250	250	Max. 0.05	0.05	0.01
Cu	2	Max. 0.05	1	Max. 1	1	1	-----	1	0.5	-----	1	1	2

Aslam, 2016

Chemicals parameters for drinking water quality included in Table 2B are cyanide (CN), fluoride (F), lead (Pb), mercury (Hg), Nitrate (NO_3) and nitrite (NO_2).

Pakistan standard value (0.05 mg/l) for cyanide (CN) and four other Asian countries such as China & India (Table 2B) is lower than WHO (0.07 mg/l) whereas three Asian countries standard value (0.01mg/l) for CN is even lesser than WHO. Nepal & Philippines standard value for CN is as same as WHO. Pakistan & Nepal have same WHO standard value (1.5 mg/l) for fluoride (F). Six Asian countries standard value for fluoride are lower (0.8 – 1.0 mg/l) than WHO. Japan standard value for fluoride (F) is the lowest (0.8 mg/l) and that of Singapore & Vietnam, both have the highest value (2.0mg/l), among all the studied Asian countries (Table 2B). In case of lead (Pb), Pakistan shares the standard value (0.05 mg/l) as that of Korea, Indonesia, Singapore and Vietnam, which is high as compared to that of (0.01 mg/l) India, Sri Lanka, Nepal, China, Japan, Malaysia and WHO. Philippines has the highest standard value (1.01 mg/l) for lead (Pb) among all the studied Asian countries (Table 2B). In case of mercury (Hg), Pakistan has same standard value (0.001 mg/l) as that of six other Asian countries (Table 2B) which is lower than that of WHO (0.006 mg/l). Japan and Singapore has, respectively, the lowest (0.0005 mg/l) and the highest (1.0 mg/l) standard value for mercury in drinking water. Four Asian countries (including Pakistan) have the same standard value for nitrate (NO_3) as that of WHO (50 mg/l). China, Korea & Japan standard value (10 mg/l) for nitrate are lower than these four countries and WHO. 45 mg/l is the standard value for nitrate in India & Vietnam (Table 2B)

Pakistan, Sri Lanka & Philippines (Table 2B) standard value for nitrite (NO_2) in drinking water is same as that of WHO (3 mg/l), whereas Singapore has the lowest (0.005 mg/l) and Japan has the highest value (10 mg/l). For bacterial parameters in drinking water, all selected countries follow the same guidelines as set by the World Health Organization (WHO).

Table 2B: Drinking water quality chemical parameters

Parameter	Standard Values For Asian Countries											
	Pakistan	India	Sri lanka	Nepal	China	Japan	Korea	Malaysia	Indonesia	Singapore	Philippine	Vietnam	WHO

Chemical Parameters													
Toxic Inorganic (mg/l)													
CN	≤0.05	Max. 0.05	0.05	Max. 0.07	0.05	0.01	ND	-----	0.05	0.01	Max. 0.07	0.01	0.07
F	≤1.5	Max. 1	1	0.5-1.5	1	0.8	----	-----	1	2	Max. 1	2	1.5
Pb	≤0.05	Max. 0.01	0.01	Max. 0.01	0.01	0.01	0.05	0.01	0.05	0.05	Max. 1.01	0.05	0.01
Hg	≤0.001	Max. 0.001	0.001	Max. 0.001	-----	0.0005	ND	0.001	0.001	1	Max. 0.001	-----	0.006
No_3	≤50	45	50	Max. 50	10	10	------	10	ND	45	Max. 50	45	50
No_2	≤50	------	3	------	------	10	-----	-----	ND	0.005	Max. 3	-----	3

ND = Not Detected
Aslam, 2016

4. Conclusion and Recommendations

As evident from the comparative data in Tables 1 & 2 and the discussion described in section 3 above, the Pakistan national standard values of a few parameters are of serious concerns and need to be reviewed and revised at the earliest. However, for most of the parameters, Pakistan follows drinking water quality guidelines/standards set by WHO (Pak-EPA, 2008 & The Gazette of Pakistan, 2010).

The overall comparison of drinking water quality standards of Pakistan with 11 selected Asian countries, shows mixed trends of lower and higher standard values for drinking water quality for Pakistan, but none of the Pakistan drinking water quality standards (Table 1 & 2) is the highest or the lowest compared to the other selected 11 Asian countries.

Only for one parameter (chromium), all selected Asian countries (Table 2B) as well as Pakistan, follow WHO standard value (0.05 mg/l).

Drinking water quality parameters of serious concern, regarding Pakistan national quality standards for the same are total hardness, total dissolved solids (TDS), arsenic (As), cadmium (Cd), copper (Cu) & lead (Pb) and these need to be reviewed at the earliest and revised as recommended below:

- total harness value (500 mg/l) to at least WHO maximum value of 300 mg/l
- total dissolved solids (TDS), presently same as WHO (1000 mg/l), to lesser value (500 mg/l) as is for Sri Lanka, India, Indonesia & Philippines.
- Lead & arsenic (0.05mg/l) to WHO value (0.01 mg/l) which is also the standard for other 6 & 5 Asian countries, respectively (Table 2A & 2B)
- for cadmium (Cd) it is extremely relaxed (0.01mg/l) compare to WHO value (0.003 mg/l) which is also the same for Nepal, Sri Lanka, India, Malaysia & Philippines (Table 2A).
- Copper (2.0 mg/l), presently same as WHO, to 1.0 mg/l, as is for 7 other Asian countries (Table 2A).

Pakistan should also consider and include additional parameters like pesticides, phenolic compounds, sulfates and other hazardous aromatic hydrocarbons (PAHs), to national drinking water quality standards.

The health effects of microbial and chemical contamination of drinking water have been reported in many studies (summarized in Annex 2) and it is direly needed that drinking water quality is addressed on priority to safeguard public health, especially of children. Pakistan needs to review and revise its drinking water quality standards, especially for total hardness, lead, cadmium and arsenic which are higher than the WHO drinking water quality standards.

The alarming high levels of arsenic and fluoride contents in drinking water for general public consumption need immediate attention towards raising public awareness, especially in the rural areas and reduction of the same, employing all available treatment technologies, including introduction, promotion and support to household water treatment systems HWTSs (khwaja et al. 2011).

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Annexures

Annex 1: Pakistan National Standards for Drinking Water Quality (2010)

Parameters	**Standard Values**	**Parameters**	**Standard Values**
Physical Parameters			
Color	≤ 15 TCU	Taste	Non-objectionable/ Acceptable
Odour	Non-objectionable/ Acceptable	Turbidity	< 5 NTU
Total hardness as $CaCO_3$	< 500 mg/l	TDS	< 1000 mg/l
pH	6.5-8.5		
Chemical Parameters			
Essential Inorganic	***mg/l***	***Essential Inorganic***	***mg/l***
Aluminum (Al)	≤ 0.2	Antimony (Sb)	≤ 0.005
Arsenic (As)	≤ 0.05	Barium (Ba)	0.7
Boron (B)	0.3	Cadmium (Cd)	0.01
Chloride (Cl)	< 250	Chromium (Cr)	≤ 0.05
Copper (Cu)	2		
Toxic Inorganic	***mg/l***	***Toxic Inorganic***	***mg/l***
Cyanide (CN)	≤ 0.05	Fluoride (F) *	≤ 1.5
Lead (Pb)	≤ 0.05	Manganese ($Mn2^{1}$)	≤ 0.5
Mercury (Hg)	≤ 0.001	Nickel (Ni)	≤ 0.02
Nitrate (NO_3) *	≤ 50	Nitrite (NO_2) *	≤ 3
Selenium (Se)	0.01	Residual chlorine	0.2-0.5 at consumer end 0.5-1.5 at source

* Indicates priority health related inorganic constituents which need regular monitoring.

Zinc (Zn)	5.0		
Organic	***mg/l***	***Organic***	***mg/l***
Pesticides	-------	Phenolic compounds (as phenols)	-------
Polynuclear aromatic hydrocarbons (PAHs) (g/l)	-------		
Radioactive	***(bq/l or pci)***	***Radioactive***	***(bq/l or pci)***
Alpha emitters	0.1	Beta emitters	1

(Source: Aslam, 2016)

Bacterial Parameters

1. E.coli or thermotolerant coliform bacteria must not be detectable in any 100 ml sample of all water intended for drinking.
2. E.coli or thermotolorent coliform and total coliform bacteria must not be detectable in any 100 ml sample of treated water entering the system.
3. E.coli or thermotolorent coliform and total coliform bacteria must not be detectable in any 100 ml sample of treated water in the distribution system. In case of large supplies, where sufficient samples are examined, these bacteria must not be present in 95% of the samples taken throughout the period of 12 months.

Annex 2: Health impacts of deteriorating drinking water quality (DWQ) due to chemicals:

Like microbial contamination, chemical contamination also poses serious health risks to infants and children health, hence, making them susceptible to various diseases (WHO, 2011).

DWQ Physical parameters pH, total dissolved solids (TDS) and total hardness (TH) are routinely measured basic DWQ parameters and these immediately give an overall general status of the DW quality. Their health impacts are much less toxic/hazardous compare to the chemical/inorganic parameters. pH, high TDS & TH may affect drinking water taste. pH may provide suitable environment for pathogens. Too high concentration of hardness and TDS on times cause diarrhea (Shigeta, 2001, Aslam, 2016 and Daud et al. 2017)

Heavy metals chronic toxicity from drinking water exposure pathway includes a wide range of adverse health effects. Nearly all organs systems are involved, mostly central nervous, cardiovascular, hematopoietic, gastrointestinal and renal system (Ferrante et al. 2014).

In children ***arsenic*** toxicity is found to be the cause of neurological impairment and intellectual dysfunctionality (Naujokas et al. 2013). Exposure to arsenic-contaminated drinking water during pregnancy is associated with reduced birth weight, and infant mortality (Smith and Steinmaus 2009). Long-term daily intakes of ***copper*** below recommended requirements can lead to anemia, neutropenia and bone demineralization in malnourished children (Ferrante et al., 2014).

The adverse health effects from exposure to ***lead*** via drinking water are well-documented in children and adults (Shigeta, 2001, Aslam, 2016 & Daud et al. 2017)

Mercury is primarily distributed through drinking water, in the kidneys and brain and readily transferred to the fetus via the placenta. For this reason mercury could be responsible for birth defects and miscarriages (Ferrante et al., 2014).

Various studies have reported the incidence of dental and skeletal fluorosis among children and the root cause of these diseases have found to be the excess amount of ***fluoride*** in drinking water (Mohsin et al. 2014).The prevalence of dental fluorosis was found to be 53.33 % in a reported study samples and most cases were of mild category. In Manga Mandi, an area near Lahore, 124 children were found to be suffering from skeletal fluorosis due to high fluoride content in their drinking water. Similarly it was found by another study conducted in Kalalanwala near Lahore that more than 400 people were having bone diseases with majority of children (72% patients were under 15 years of age). High concentration of fluoride in drinking water was traced as the reason of these numerous cases of bone diseases in the studied area (Azizullah et al. 2011).

Nitrate can interfere with the ability of the blood to carry oxygen to vital tissues of the body in infants of six months old or younger, causing methemoglobinemia, or "blue baby syndrome" (Woolverton 2015). High levels of nitrates can also be the cause of increased risk of respiratory tract infections and goiter development in children (Azizullah et al. 2011).