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Review Article

Water Quality Assessment in Sindh, Pakistan: A Review

Seerat Ul Ain Bhutto[1], Sanjrani MA[2]* and Mutaharat Ul Ain Bhutto[3]

[1]*School of Environmental Studies, China University of Geosciences Wuhan, China*

[2]*School of Resources and Environmental Engineering, Wuhan University of technology, China*

[3]*MA Kazi Institute of Chemistry, University of Sindh Jamshoro, Pakistan*

***Corresponding author:** Sanjrani MA, School of Resources and Environmental Engineering, Wuhan University of technology, China

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Abstract

Increasing detrimental impacts of water pollution on environment and serious health issues, this review aims to investigate water quality status of Sindh, Pakistan.it also help us to determine current and future water demand of the province as well as adverse impact on human health in regards with water borne disease. To conclude, some recommendations are also outlined.

Keywords: Water borne disease; Quality assessment; Water supply; Water contamination; Sindh; Pakistan

Introduction

Although surplus amount of water is available on the planet of earth, but only small portion is available for human utilization. Overall population wholly depend upon the water sources mainly consist on groundwater and surface water. Currently, countries around the world are facing water pollution as well as water scarcity problems. Following the report of UN, the total populace increases exponentially while accessibility of water decline with time. WHO announced that by 2025, half of the total populace will live in water-stressed zones? Unfortunately, water pollution stresses the remaining small portion. During last decades, Urbanization and industrialization further added burden on water resources around the globe. Quality of water around the world has been deteriorated with chemicals discharged into water bodies directly and improper dumping of solid waste. According to Joint Monitoring Programme (JMP) report 2017 on "Progress on drinking water, sanitation and hygiene" 2.1 billion people lack access to safe drinking water at home. Globally, 448 million lack to have basic drinking water services from which 159 million individuals are those who rely upon surface water. According to speech of UNO secretory on world water day 2002, each year 5 million people died of water disease i.e.10 times more than people died in war. Furthermore, several studies have documented various contaminants such as organic (Pesticides), inorganic (heavy metals), minerals (arsenic and chromium) and microbial (pathogens) are responsible for water pollution. Recently, water contaminated with arsenic has been documented around the world, especially in Asian countries including Pakistan, Bangladesh, India, Cambodia, Vietnam, China, Taiwan, Hungary, Chile and Argentina [1-4].

Pakistan has been blessed by natural resources i.e. surface as well as groundwater resources. Sudden rise in population, industrialization and urbanization have brought huge stress on water resources of country. The country once has surplus amount of water is not including in water stressed zone. Most of the population belong to different cities of country rely upon groundwater for survival. While, current water supply is about 79% in Pakistan. Pakistan has experienced six noteworthy floods between 2000-2015, which killed many people and posed negative impact on groundwater through salinization CRED [5]. Furthermore, Per capita availability of water has been decreased from 5,600 cubic meters in 1947 to 1,038 cubic meters in 2010. It is expected to decrease further to 575 cubic feet in 2050 [6,7]. In addition to this, quality of water resources has been declined due to intermixing of municipal sewage with water supply line and direct release of industrial wastewater into water bodies. Pollutants such as heavy metals, pathogens and other dangerous chemicals have been found in different regions of the country. Only 20% of the population have accessibility to safe drinking water while 80% is compelled to consume unsafe water for drinking. Each year 2.5 million deaths

from endemic diarrheal disease has been reported [8-13]. Pakistan ranks 80th, out of 122 nations of the world, on the basis of water quality [14-16]. According to a Worldwide Fund for Nature (WWF) report titled, "Pakistan's Waters at Risk"20-40% health centers are filled with the patients of water borne disease which include diarrhea, gastroenteritis, typhoid, cryptosporidium infections, giardiasis intestinal worms, and some strains of hepatitis [17].

Quality of drinking water in Sindh province is unfit like other provinces of Pakistan. Large portion of water available is contaminated with pathogens, chemicals and toxic materials. Several studies have documented that the four major contaminants are responsible for water quality deterioration in Sindh i.e.69% bacteria, 24% arsenic, 14% nitrate and 5% fluoride. According to the report of Inquiry commission appointed by Supreme Court of Pakistan "78.1 % of all water sample tested were found unsafe for drinking". The aim of this review is to analyses the status of water quality in different divisions of Sindh, Pakistan. It also describes the impacts of water quality on human health as well as outline some recommendations.

Study Area

Sindh is second most populated province (Figure 1) with population of 30.44 million situated in south-eastern part of Pakistan. It is stretched from 66°8' East Longitude to 71°, lies between 24°4›N to 28°7'N and covers about 46,569 miles^2. Province is bounded by the Thar Desert to east, the Kirthar Mountains to the west, and the Arabian Sea in the south. It is divided into six divisions namely Karachi, Hyderabad, Sukkur, Shaheed Benazirabad, Mirpurkhas and Larkana. Karachi i.e. the capital of Sindh province ranked at the top with 14.91 million and Hyderabad ranked the 8th most populated with 1.73 million population among the list of 10 most populated cities of Pakistan. Large number of populations of the province depend upon the fresh water for domestic and irrigation purpose. Indus basin is the major source of water provision in the area. In Sindh Province, only 10 % of land area had availability of fresh groundwater and occurs in shallow aquifers [18]. Following high average annual temperatures, semi-arid climate, sea water intrusion and high rate of evapotranspiration shallow aquifers are highly saline [19]. Irrigated land i.e. almost 78% of the province rely on saline groundwater which is not fit for irrigation. As the ground water is saline in most areas, rural population is also depending on supplies from the canal system. According to the survey conducted by Pakistan Council of Research in Water Resources (PCRWR) in 22 districts of Sindh province out of 1247 surveyed water supply schemes only 529 (42%) were functional with average duration supply of 5 hrs/day. From which only 25% water samples were fit for drinking while remaining are contaminated with micro-organisms and arsenic.

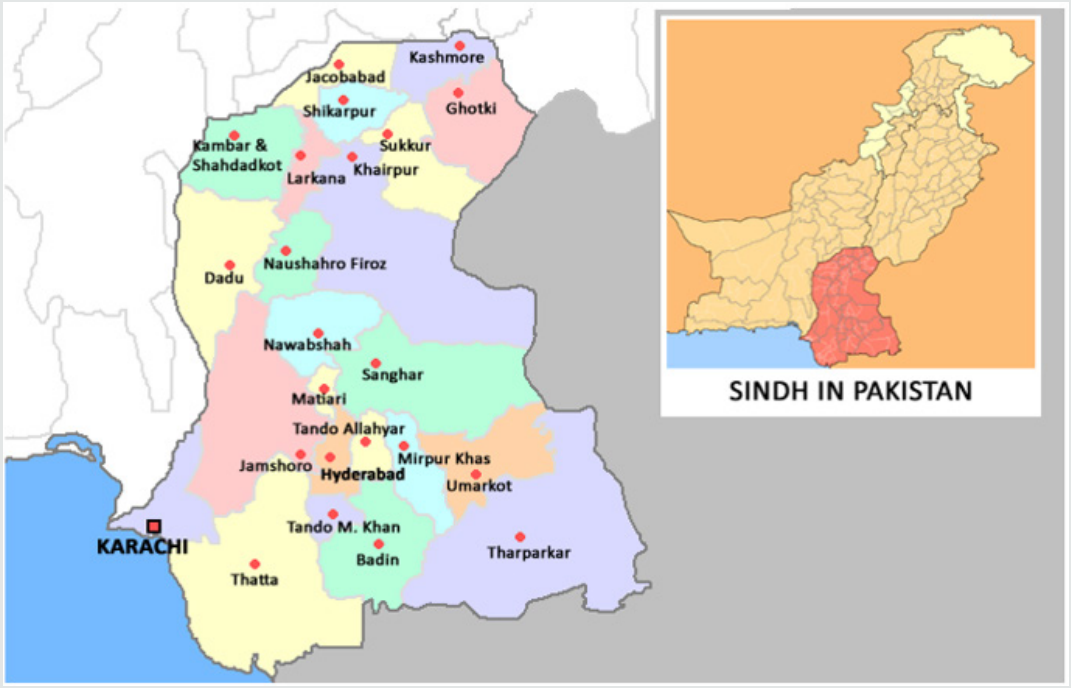

Figure 1: Map of Study Area (Sindh Pakistan). Source: Modified from (Sindhidunya 2015).

Current Demand and Future Requirement of Sindh

In next 20 years, Province will undergo demographic change. Current population of 33 million is expected to increase to 52.6 million and urbanization will increase from 50% to 64% in 2025. Currently, Karachi's demand for water supply is about 1,220 MGD against which has an allocation of 34,000 l/s (1,200 cusecs) from the Indus water which is expected to increase 65,460 l/s (2,320 cusecs), with increased population to about 23 million in 2025. Likewise, water demand for other urban cities will also increase which will put burden on water resources. In addition to this, rural population of about 18.8 million will need an additional

about 7,125 l/s (250 cusecs) for drinking purposes. Hence, total municipal water requirement of the province in 2025 will be of the order of 94,000 l/s (about 3.300 cusecs). Besides municipal water requirement, water requirements for agriculture would also increase by about 50%. Current water use is about 52.6 Bm3 (42.6 MAF) which means an additional 26.3 Bm^3 (about 21.3 MAF) required to meet the future demand of agriculture products (FAO).

Water Quality

Alarming increase in population is the single important driving force affecting the water sector and cause water scarcity problem in the province. Water pollution is another major problem which is deteriorating the quality of remaining small portion of water. According to Director General of Sindh Environmental Agency Baqa Ullah Unar "every day almost 500 million gallons of industrial waste and human consumption falls into Arabian Sea".

80% samples from 14 different districts of Sindh are not safe for drinking as well as 78% of water used in hospitals is above standard limits. 90% of water had bacterial contamination and not fit for drinking in Karachi only (PCRWR). Several studies have been conducted in different cities of Sindh, Pakistan (Table 1) [20-29].

Table 1: Water quality in different districts of Sindh, Pakistan [20-29].

S no	division	Area	pH	EC	Turbidity	Hardness	TSS	TDS	Arsenic	E.Coli	Reference
1	Karachi	Karachi	7.1	402	3.5	123		289		Present	Khan S 2018
		Malir			13.8	1610		3725	5	Present	Suresh Kumar Panjwani 2018
		Orange town						100		80.43	A.Alamgir 2015
2	Hyderabad	Hyderabad	7.4	584	5	170		373	6.51–9.98	Present	Khan S 2018
		Jamshoro	7.41	1764.4	6.31			1064.84	6.66		Muhammad Haneef Mugheri 2019
		Thatta	7.32		32.73	796	150.3	1099	5	1684.64	Alamgir, A 2016
		Keejhar lake	7.2	637.2	2.317			273.1		3.571	Muhammad Afzal Farooq 2013
		Badin	7.5	1355	0.37			677			Sanjrani MA 2018
		Dadu	7.98	2.86	9.73			1832	24.78	22.56	Memon AH 2016
3	Shaheed Benazirabad	Shaheed Benazirabad	8.18			13200		22912	52.3–85.2		Muhammad Yar Khuhawar 2010
		Naushehro Firoz							18.0–50.6		Jameel Ahmed Baig 2016
4	Larkana	Shikarpur	7.3	620		238		695		Not present	Khan S 2018
		Jacobabad	7.8	2544		680		1650		Present	
5	Mirpurkhas	Mirpurkhas	7.1	2030		430		1292		Not present	Khan S 2018
		Tharparker	7.98	1095.9		264.58		701.43	6		Khuhawar MY 2019
6	Sukkur	Sukkur	7.2	648	4.5	239		487	26.0–98.2	Not present	Khan S 2018
		Khairpur	7.8	50		13.11		20.5		Not present	A.R.Shar 2014
		Rohri	7.41	1570.97	7.82	421.12		993.92	21.95		Muhammad Afnan Talib 2019
		Ghotki	6.9	1858		530		980		Present	Khan S 2018
WHO			6.5-8.5	1562µS /cm	< 5 NTU	500 mg/L	5 mg/l	1000 mg/L	10 ppb	0 CFU	WHO guidelines 2011
NSDWQ			6.5–8.5		<5 NTU	<500	NA	<1000	50ppb	0 CFU	EPA 2010

Abdul Hussain Shar [30] analysed the samples from Rohri for the presence of total coliform (TC), *E. coli* (Ec) and heterotrophic plate count (HPC) which result the contamination of all samples with TC (100%), Ec (41.6%) and with HPC (100%). In Hyderabad bacteriological tests on drinking water has been conducted by PCRWR found that 15 monitored sources as unfit for drinking mainly due to bacteriological contamination (93pc), excessive levels of iron (47pc) and turbidity (93pc). Mashiatullah [31] carried out a study on Malir and Lyari rivers, he analysed different Physiochemical and biological parameters. The coliform contamination i.e.156-542 per 100 ml in high tide and 132- 974 per 100 ml in low tide were observed which exceeded WHO guidelines. Aziz et al. [32] reported a study for drinking water quality in Pakistan including both urban and rural areas which results that total coliform and fecal coliform were 150–2400/100 ml and 15–460/100 ml respectively. The investigation reported the presence of anthropogenic activities which resulted.

Mahmood et al. [33] measured the physical, chemical and microbiological parameters for the different groundwater samples collected from Thatta in pre-monsoon and post-monsoon seasons, respectively. It was observed that concentration of heavy metals were; As (0.0045 to 0.0055 mg/l), Cd (0.15-0.22 mg/L), Zn (0.040 to 0.046 mg/l), Pb (1.40-1.49 mg/l) and Cu (0.001- 0.87 mg/L) in both the seasons and were in order of Pb > Cu > Cd > Zn > As in pre-monsoon and Pb> Cd > Cu > Zn > As in post- monsoon respectively. Other parameters Electrical conductivity (233-987 µs/cm), pH (6.9-8.9), TDS (161.1-690.9 ppm), Temperature (24-33°C), chloride (81.79-131.78 ppm), total hardness as $CaCO_3$ (124.40-188.81 ppm), nitrate (2.10-5.20 ppm) were within prescribed standard limits. Some common diseases were found to be nausea, vomiting and kidney damage.

Suresh Kumar Panjwani [34] collected Thirty-five groundwater samples and analysed for 22 different parameters including physicochemical parameters and bacteriological contamination. Three drinking water samples (9%) contain Fluoride as 1.83 mg/l to 0.44 mg/l which exceeds WHO limits. Two water samples (5%) were contaminated with nitrate–nitrogen i.e. 23.61 mg/l to 0.97 mg/l. (45%) 16 water samples were contaminated with *E. coli* ranges from 01-too numerous to count CFU/ml exceeding the prescribed limit by WHO (0/100ml). None of the drinking water samples (0%) were found bacteriological safe for drinking purpose. In 2014, another study examined water quality in Thatta, Karachi and Hyderabad found presence of heavy metals that exceeded the WHO drinking water guidelines [35].

Outbreak of Water Borne Disease

Improper treatment and dumping of waste in water bodies accounted for rise in water borne disease. Deteriorated quality of water in Sindh province had badly affected the human health. More than 20,000 children die annually in Karachi only, from which majority of deaths caused by drinking contaminated water. Outbreak of water borne disease have been noticed in different parts of Sindh including typhoid, cholera and diarrhea. According to Zahid J [36] areas surrounded by poor households, children with mothers married in early ages, children having small size at birth and ages less than 24 months and children belonging to uneducated mothers are found most vulnerable where prevalence of diarrhea found non-ignorable. In Sindh, Tando Allahyar (46%), Matiati (50%), Hyderabad(44%), Badin (40%), Mirpur Khas (40%) Karachi East (40%) and Karachi South (52%) have highest rate of cases while lowest rate found in children from rich house holds' of Larakana (6%) and Jacobabad (8%). In some areas including Gadap, Kathore and coastal areas 30-35% of people have been found infected with viral hepatitis. While 20-25% of the population is infected with the deadly viral disease said by Dr Shahid Ahmed, consultant gastroenterologist and patron of the PGLDS on World Digestive Health Day 2018 (WDHD 18).

Recently, a drug-resistant typhoid strain identified first in Hyderabad, spread from the city to various parts of the country. 5,274 cases of XDR typhoid have been reported by Provincial Disease Surveillance and Response Unit (PDSRU) from 1 November 2016 through 9 December 2018.69 % (3658) of cases were reported in Karachi only, following 27% (1405) in Hyderabad, and 4% (211) in other districts of the province. On 9th July 2017, outbreak of acute watery diarrhea and abdominal pain in village Mir Khan Otho, District Shaheed Benazirabad were reported to the DG Health Office Sindh in Hyderabad. A total of 30 cases were identified (22 through active case finding) and n=16 (53.7%) were females. Mean age was 25.3 years (range: 1-50 years). Overall attack rate was 23%. People aged 21-30 years were the most affected (n=10; AR 43.5%). Apart from diarrhea, abdominal cramps (n=28; 93%) was the most common symptom. On bivariate analysis, consumption of water from the hand-pump near the swamp was significantly associated with the disease (OR=8.4, 95% CI: 3.1-22.7) [37].

In 2016, 22,000children have been hospitalized and more than 190 have died in Tharparkar district due to drought-related waterborne and viral diseases. According to the Joint UN Needs Assessment, water scarcity has been severely affected several districts (62% in Jamshoro and 100% in Tharparkar) which resulted in reduced harvest by 34-53% and livestock by 48% UNICEF [38]. According to local media, the total under- 5 deaths were rising from 173 in 2011, 188 in 2012, 234 in 2013, 326 in 2014, and 398 in 2015. According to the provincial health secretary, 450 children lost their lives in 2017, 479 died in 2016 and 398 in 2015 while reasons for the deaths vary. Furthermore, According to authorities in Tharparkar district, Sindh province, 99 children and 67 adults (43 men and 24 women) have reportedly died in Tharparkar since the beginning of 2014 as well as an outbreak of sheep pox occurred which has killed thousands of small animals (Pakistan: Drought - 2014-2017) [39]. Furthermore, three months after floods began in Pakistan, 99 cases of cholera were reported from across the flood-affected areas of the country (WHO).

In 1994, first ever case of dengue has been reported in Pakistan, sudden rise in cases first occurred in Karachi in November 2005. Since 2010, Pakistan has been encountering dengue fever that has caused 16 580 affirmed cases and 257 deaths in Lahore only also about 5000 cases and 60 death confirmed from other parts of the country (WHO) [40]. The three provinces have faced the epidemic are Khyber Pakhtunkhwa, Punjab and Sindh. In Sindh province, 2088 dengue positive cases had been reported as well as two people had died of dengue in Karachi city in 2018. Currently, according to the weekly report issued by Prevention and Control Programmed for Dengue (PCPD) in Sindh, from January 1 to January 7, 2019 a total of 38 dengue positive cases were detected. From which 36 were reported in Karachi only while two were in other districts of Sindh (PPI).

Contamination Sources

Climate Change

For water resources, climate change is a long term and unmitigated risk. Water demands is expected to increase up by 5 percent to 15 percent by 2047 due to climatic change. In the upper Indus Basin, climate change will increase the risk of flood outbreak by accelerate glacial melting while in the lower Indus Basin, sea level rise and increases intensity of coastal storms also exacerbate seawater intrusion into the delta and into coastal groundwater. Furthermore, in coastal Sindh, groundwater quality will further be deteriorated and also impact the ecosystems, and irrigation productivity of the province. In addition to this, Sediment dynamics in the Indus sourcing, transport, and deposition have been significantly altered by water resources development. Past floods in Pakistan not only posed physical damage but also affected human lives in terms of flood-related death and illness as well as clean water and sanitation facilities. The flood destroyed 54.8% of homes and caused 86.8% households to move, with 46.9% living in an IDP camp. Lack of electricity increased from 18.8% to 32.9% (p = 0.000), lack of toilet facilities from 29.0% to 40.4% (p=0.000). Access to protected water remained unchanged (96.8%); however, the sources changed (p=0.000) [41].

Since 2013, Tharparkar has been influenced by a drought-like circumstance affecting employments, nourishment and wellbeing conditions. In south-eastern Sindh, low rain fall throughout 2016 in districts including Tharparkar, Umerkot and Sanghar sharply reduced the cereal production also causes loss of small animals due to diseases and severe shortages of fodder and water. Moreover, it has aggravated food insecurity and caused acute malnutrition [42].

Poor Water Supply and Sanitation

USAID reported that in Pakistan about 60% of the total number of child mortality cases are caused by water and sanitation-related diseases. Pakistan Strategic Environmental Assessment of the World Bank, 2006 stated that about 2,000 mgd of wastewater is discharged to surface water bodies in Pakistan. 13,000 tons of municipal waste daily generated in Karachi only, following 3,581 in Hyderabad while 48 million tons a year around the country. Water and sanitation sector have the highest financial cost to Pakistan from environmental degradation at Rs112bn a year as reported by WB. This is based on health cost of only diarrhea and typhoid and accounts for 1.81 per cent of the GDP. While figures for Sindh are not available. According to the media (The news) "More than 50 per cent of the people were suffering from diseases related to water and sanitation due to the lack of proper sanitation in the Sindh province" speakers told on' World Toilet Day with the 2018 theme 'Toilets and Nature, the Pathway to Neat and Clean Sindh'. In Karachi, 42 percent of the city's total population have no access to a proper toilet and appropriate sanitation system and live in 539 slums. Furthermore, Karachi Metropolitan Corporation and Cantonment boards have public toilets at only 13 places.

Poor Water Management

According to Rubina Jaffri, the general manager of Health and Nutrition Development Society (Hands), only 440 MGD is being filtered out of 640 MGD of water supplied to Karachiat seven filtration plants. A recent survey accounted that 40% water samples collected from different parts of Karachi were not properly chlorinated. In Karachi, long transmission route also causes leakages and water thefts problems which account for the loss of almost 30% of the city's water supply, said by Jawed Shamim, former chief engineer at KWSB (The Karachi Water and Sewerage Board).Moreover, Parallel water supply and sewage pipes currently lead to cross contamination and corrosion. Chief Minister Syed Murad Ali Shah, in Sindh there were 2,109 water filtration plants, including 1,620 RO plants, and 818 of them were non-functional. He also added that there were 5,091 water supply and drainage schemes and 2,494 of them were non-functional and 244 of them had been abandoned (PPI).

Agriculture sector consumes up to 90% of the available fresh water of the country. About 70% of the canal water is lost from river to the end user. The larger portion of canal water (35%) is wasted at field level which needs proper attention of the policy makers. furthermore, 30 MAF is equal to 10 trillion gallons which can feed a population of more than 500 million people has been dumped into Arabian sea instead of storage. Problem is the absence of efficient conservation, storage and usage of water [43-50].

Recommendations

a) Basic filtrations units and 24 hours water quality monitoring stations should be established

b) Proper usage, efficient storage and conservation strategies are utmost practices to deal with water scarcity problem

c) Rearranging of water supply line to deal mixing of municipal sewage into water supply

d) Latest and technical irrigation strategies to use water efficiently such as drip irrigation and sprinkling.

e) Proper waste management system and treatment of industrial effluent should strictly implement

f) Institutional capacity management in order to operate and maintain the water supply schemes

g) Proper design of water distribution network to deal with the water loss.

h) Education on the water conservation and utilization practice should be provided to people by arranging seminars and utilizing media

i) Water thief and corrupted people should be deal according to law and regulations

j) Construction of new water reservoirs and proper check in balance on old ones to enhance storage capability by resolving siltation problem

k) Encouragement of new polices and proper implementation as well as check in balance

l) Awareness campaign should be encouraged about water quality and water borne disease

m) Basic health care and relief facilities should be provided at doorsteps when needed to reduce death related to water borne disease

n) Involvement of community to reduce water pollution by providing basic knowledge and changing lifestyle.

o) Proper check in balance on water filtration plants to provide safe drinking water to communities.

p) Mitigation strategies to improve the response to climate change-induced effects on health and agriculture

Conclusion

Conclusively, water quality status of Sindh Pakistan has been reviewed. Most of the water in different areas of the province is contaminated with bacteria which causes outbreak of waterborne disease including, diarrhea, cholera, hepatitis and typhoid in many cities and caused millions of deaths simultaneously. Arsenic is the second hazardous chemical found in water of Sindh mostly in coastal areas. Fluoride and nitrite are other metal which pose threat to human lives in Sindh Pakistan. Thus, many policies have been established and many schemes were organized by provincial government to deal with the water crisis but still some gaps related to implementation exist that needs to be executed. Moreover, new reservoirs and flow distribution line should be constructed to deal with water scarcity and water loss problem of the province.

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