WATER RESEARCH ACTIVITIES IN PAKISTAN

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Abstract

Pakistan located in Southeast Asia bordering the Arabian Sea has a total area 796096 sq. km with a population of 160 million. The country is blessed with adequate ground and surface water resources. However, due to high increasing population, urbanization, industrial & agriculture growth, over-exploitation of groundwater resources and unsustainable water consumption practices, the water quality and quantity are under great stress. This results in loss and deterioration of water resources. The government, scientists and society have a responsibility to over come the fast deteriorating water quality and quantity situation in the country. Groundwater use in urban and rural areas is at its maximum usage in most parts of Pakistan resulting in declining of water-table continuously. According to a recent statistics, per capita availability of water is reduced to 1100 cm^3. Groundwater quality vary according to the area and is generally from fresh with Total Dissolved Solids (TDS) less than 1000 ppm near the major rivers to highly saline with salinity exceeding 3000 ppm. According to recent studies, high level of nitrates, fluoride and arsenic in several groundwater samples from Punjab and Sindh province have been found. Due to agriculture run-off pesticide residues are also often detected in surface water. Some low cost technologies are being developed for the removal of these pollutants from water but the work is under going trials before being used for commercial purpose. Sea water on the sea shore is also being increasing polluted due to the discharge of untreated industrial effluent consequently polluting the aquatic life. To combat the above problems in Pakistan, research on various water related issues are being pursued which include the following; water management, quality assessment, sources of pollution and purification. Several public sector universities, scientific organization namely Pakistan Council of Research on Water Resources (PCRWR), Pakistan Council of Scientific and Industrial Research (PCSIR), National Institute of Oceanography (NIO), Agriculture Research Council (ARC) etc. are engaged in water related research activities in the country.

1. Introduction

In recent years water has became one of the most critical issue across Pakistan, the reason being its scarcity which has markedly effected the urban and the rural population in terms of its quantity and quality. During last two decades the increasing trend on urbanization, industrialization and agriculture growth which in addition to large population has aggravated this problem. On one hand there is not enough water available for cultivation of sizeable area of agriculture land in Sindh and Baluchistan provinces and on the other no urban water supplies in the country meets WHO drinking water quality guidelines. These two are among major socio-economic issues for Pakistan. Mean annual rainfall in Pakistan varies from less than 100 mm in Balochistan and parts of Sindh provinces to over 1500 mm in the foothills and northern mountains of Pakistan.

Several efforts are being made by the government and the scientific community to provide better solution to the problem for the nation. However, there are some obstructions which hinder the process and consequently make it ineffective. Water related research activities in Pakistan are generally confined to the following areas, each of which is discussed separately:

1.1 Water Management / Saving Technology

Profound demographic and economic changes in Pakistan have major implications for water management both in the rural and the urban sector. Population is increasing at the rate of 2.8% and is expected to be 230 million by 2025. The trend of rapid increasing urbanization from 20 million in 1980 to 80 million in 2002 showed that the water demand will continue to increase.

Rural water management: In Pakistan agriculture contributes to about 22 % of the GDP and more than 60 % population depend upon agriculture practices hence water availability is a crucial issue. Current water availability is reduced to 1100 m^3 per capita from 5000 m^3 per capita over last 5 decades and is estimated to be 700 m^3 by the year 2025 [1]. River Indus is one the main source of agriculture followed by groundwater. Irrigation uses 93% of water currently available in Pakistan, rest is used by urban, rural and industrial sector.

In rural area groundwater is the major source of drinking water, however, other sources are river, canal and dug well. The province of Punjab has the best rural water supply system in the country.

On the agriculture side research is being focused on improving water use efficiency through on-farm water management by adopting water use efficiency sprinkler and drip irrigation techniques, developing innovative water saving practices such as bed planting and zero-tillage techniques, developing laser levelers for leveling agricultural fields, etc. [2, 3]. Beside these Innovative water resources management activities are being introduced to overcome the water shortage in water scarce areas of Pakistan.

Urban water management: In view of the water scarcity, a major challenge faced by the country is up-gradation of the water resources, in urban areas and industrial estates, which are undergoing degradation due to lack of management of sewage and industrial effluents. Water leakage, theft and the mixing of sanitary and industrial effluents into freshwaters must be blocked permanently [4].

A collaborative research project titled "*Capacity Building in Urban Water Demand Management*" through DELphe funding is under progress in author's laboratories. Since several urban areas in Sindh province are under severe water stress hence this study is most appropriate to overcome domestic water shortage is cities. The purpose of this research is to develop low cost technologies for the treatment of toilet waste water known as *grey-water* and to reuse this for non-drinking purposes. The following technologies are being worked out:

Reed Beds Treatment: Reed beds are a natural habitat found in floodplains, waterlogged depressions and estuaries. The reed bed treatment systems does not require any power, chemical, manpower to operate and is generally do not need any maintenance / monitoring and often produces better quality water than the well operated conventional treatment systems.

Rotating Biological Contactor is of secondary treatment process. The technology which allows the greywater to come in contact with a biological medium before reuse.. It consists of a series of closely spaced, parallel discs mounted on a rotating shaft which is supported just above the surface of the greywater. Microorganisms grow on the surface of the discs where biological degradation of the greywater pollutants takes place.

The Green Roof Water Recycling System (GROW) is a kind of new recycling system for greywater. Planted roof-top troughs clean the greywater and return it via a pumping system. It can be used for gardening as well as toilet flushing. There are two types of GROW viz. Horizontal GROW and Vertical GROW. Detailed information may be obtained from the website of the Center [5].

Research is also being focused to overcome the shortage of water in the rural and urbal areas of Pakistan through Rainwater harvesting – a process of collecting, filtering and storing water from roof tops, paved and unpaved areas for multiple uses. Recent innovations in traditional systems have made rainwater harvesting techniques more hygienic and acceptable to rural community. More attention is being focused to harvest rainwater in water scarce areas with active involvement of user groups to make best use of this natural gift. Another approach towards water saving technologies in urban areas is leak management and water metering schemes which are being implemented not only to overcome water shortage but also to minimize pollution. These efforts will help reduce the gap between water demand and supply in the country.

1.2 Water Quality Assessment, Sources of Pollution

Water pollution in Pakistan is due to agrochemicals, petrochemical, textile, sugar and tannery industry. The agriculture drain are saline with high TDS, high COD and BOD. Sugarcane based industry the 2nd largest in the country is a major cause of industrial pollution. Over 80 industries installed capacity is 360,000 tonnes of sugar / day generating several thousand cm^3 wastewater per day. Only few industries have wastewater treatment facility and adopt environmental assessment policy [6]. Major portion of industrial effluent and urban wastewater is discharged untreated into the river and the Arabian Sea. Studies reveal the presence of toxic metals mercury, cadmium, chromium, lead, arsenic, and zinc in the effluents, river and sea water [7]. The effluents are mainly released untreated into the environment by the industrial estates. An IUCN study showed that poultry feed, made of locally caught fish, chicken and eggs contained varying level of chromium.

Tubewells systems are the main source of water supplies in cities. This system is no more safe due to increase in urban population over the years. Large quantities of industrial and municipal effluents loaded with toxic chemicals as well as pathogens make the water supply schemes virtually unfit for human consumption. The quality of groundwater ranges from less than 1000 ppm to more than 3000 ppm. Some 5.75 million ha are underlain with groundwater having salinity less than 1000 ppm, 1.84 million ha with salinity ranging from 1000 to 3000 ppm and 4.28 million ha with salinity more than 3000 ppm [8]. The water of the Indus River and its tributaries is of acceptable quality. The total dissolved solids (TDS) range from 60 to 374 ppm, safe for irrigated agriculture, domestic and industrial uses [9].

In some groundwater of Pakistan only traces of mercury were reported to be detected which were below the WHO guidelines (0.001 mg/L), however drains and polluted Manchar lake in Sindh province does contain significant amount of mercury beside other pollutants and high TDS, due to industrial discharge [10,11].

The presence of pesticide residues in water is also a serious issue. WHO guidelines show that no pesticide is to be present in drinking water while it should not exceed above 0.005 ppm in surface water. According to a report [1] 5.6 million tons of fertilizer and 70 tons of pesticides were consumed in Pakistan annually in 2003 and these have increased at the rate of 6 % annually since then. These pesticides mix with the irrigation water leaches through the soil and enters ground acquifiers. The same report shows that out of 107 samples of groundwater collected from different agriculture areas during the year 2000, 31 were found to contain pesticide residues above the WHO limits. Due to continuous increase in these agrochemicals the contamination levels are likely to have increased significantly. Another survey showed traces of DDT and its metabolies, carboryl, carbofurane and diazinone in irrigation water of Punjab province [12].

Recently arsenic have been reported into underground water in Southern Punjab and Sindh provinces [13,14]. Due to the imminent threat of inorganic arsenic on human health the PCRWR with the assistance of UNICEF have carried out a detailed survey through its Water quality monitoring program. In underground water samples from 5 districts of Punjab and two of Sindh arsenic levels arsenic level was found to be in the range of 30 to 50 ppb which is above the safe limit of the WHO. However, the intensity of arsenic in the groundwater was comparatively less than that of Bangladesh. Several researchers are working on the determination of pollutants in water. It is suggested that high levels of arsenic in urban areas is due to pollution from untreated sewage, causing hydrous ferric oxide (HFO) to release arsenic into shallow groundwater [13]. However, arsenic in groundwater from rural areas was also found to be in far more than the allowable limits even where there is no sewage contamination problem. Research conducted by PCRWR on drinking water bottles (called as mineral water) shows that 23 out of 59 water bottles were contaminated with varying levels of arsenic. A list of these companies is available on PCRWR website [15].

To strengthen the above findings UNICEF and the UNDP have initiated a “Innovative Low Cost Arsenic Removal Technologies” to combat the arsenic contamination in drinking water for rural and poor communities of the country. This technology has been tested and being adopted in different arsenic affected regions of Pakistan to supply arsenic free water [13, 14].

Varying levels of nitrates in underground waters in Pakistan and their possible sources have been reported by some workers [16-18]. However in less than 25 % samples of water nitrate level were reported in Karachi city, to be above the permissible limits of the WHO, the major source being industrial and domestic water pollution [18]. Likewise nitrate burden is also reported in the underground water of Northern Punjab of Pakistan [19]. Nitrates were found in most of the water samples ranging from traces to the maximum of 1125 mg/L in Haripur well water. Removal technologies for nitrates such as ion-exchange, reverse osmosis and chemical reduction are being used with slight or no modifications. The author concluded that agriculture fertilizers are the direct source of nitrates e.g. ammonium and calcium nitrate.

Fluoride a water pollutant, is also investigated and found to be present in high concentration than the WHO guidelines in underground water samples of Sindh and Punjab provinces [20]. The source of fluoride ion is the fluorine bearing minerals which run obliquely through Punjab province. Recently an integrated study on fluoride ion contamination in underground water of Thar desert of Pakistan has been carried out to determine its occurrence, spatial distribution and geochemical process controlling the high concentration [21]. The area is covered with sand dunes and kaoline / granite at variable depth. In the entire area groundwater is the only source of drinking for over 2 million inhabitants. Fluoride concentration ranged between 0.09 to 11.63 mg/L in 424 samples of water collected during this study. The content of fluoride ions has been correlated with major ions found in underground water of the study area. A positive correlation of Fluoride with Na^+ and HCO_3^- showed that it is stabilized due to the presence of Na^+ and HCO_3^-. The groundwater is not suitable for drinking purpose in most places as major fluorosis health problems are prevailing among the local population which is nearly two million. A plot showing the fluoride ion distribution in underground water of Thar desert Pakistan is shown in Figure -1 [22].

Another study titled biological indicators for monitoring water pollution in Khanpur canal has been carried out by Hafeez et al. [23]. which supports the hypothesis that the aquatic species of insects can be used as tools or indicator to monitor the health of ecosystem. The study was conducted at Hattar industrial area, about 69 km north of Islamabad, Pakistan to determine the impact of industrial effluents on the population dynamics of aquatic insects. The water quality of Khanpur canal before industrialization of area confirmed the set Pakistan National Environmental Quality Standards (NEQS). The water quality, since then, has deteriorated in terms of its pH, Biological Oxygen Demand, Chemical Oxygen Demand, chloride, nitrate and total suspended solids were manifold higher than NEQS. The deterioration of water quality has a direct impact on the population of species of aquatic insects. This study supports the hypothesis that the aquatic species of insects can be used as tools or indicator to monitor the health of ecosystem.

Most of the research on water reported from various universities in Pakistan shows a trend of studying the nature and extent of pollution. Figure 2 shows the number of publications on water pollution studies in Pakistani universities during last decade.

1.3 Water Purification

Various workers are working on using low cost technologies for indigenous use to remove the pollutants from water. Studies are in continuation for developing natural such as clay as well as synthetic material for the removal of fluoride from water. A low cost system is reported for the removal of arsenic from water using the Clay Pitcher filters, gravity flow cartridge filter and household arsenic removal filters. The efficiency of the three filters for domestic use were compared and reported in the literature [14].

The ionophoric properties of Calixarenes, supramolecular compounds, have been exploited for extraction of several pollutants e.g. Cd, Hg, Co, $Cr_2O_7^{2-}$ from aqueous systems. Various functionalized calixarenes have been synthesised and reported into the literature [24 - 26]. Further work is ongoing in the laboratories of the author in Pakistan for the removal of fluoride and arsenic using the above functionalized polymers [27]. In recent years several workers have reported development of low cost materials to remove toxic metal ions and trace organics including pesticides from aqueous samples through solid phase extraction. The materials used in most of the cases is agriculture waste e.g. rice husk, saw dust, sand and inexpensive synthetic adsorbents. Various parameters including mesh size, temperature, pH, adsorption isotherms and thermodynamics have been studied in details. Several of these adsorbents have the potential of removing metal ions and trace organic compounds at very low concentration in water and for use in industrial effluents.

These studies are of high academic interest with ultimate goal of being used as sorbents for water purification at commercial level [28 – 33].

1.4 Government policies

After a long time Pakistan government has issued two major policies related with water quality, use and conservation. These are *the National Drinking Water Policy (2007), National Environment Policy (2005) and the National Sanitation Policy (NSP)*. The government of Pakistan with the help of UNICEF and Civil societies has developed indigenous low cost technologies for treating contaminated water for arsenic and bacterial contamination. Funds have been allocated for arsenic mitigation measures including awareness, promotion of alternate water sources, capacity development of partners etc. Standard for Quality Drinking Water in Pakistan have also been adopted by the government in recent years [34]. Table 1 shows the details of these standards. To check the quality of industrial and municipal effluents discharged in water streams, the Pakistan Environmental Protection Agency has revised the National Environmental Quality Standards shown in Table – 2. A National Action Plan for Arsenic Mitigation (NAPAM) in Pakistan is also being finalized. In short since Pakistan is a semi-arid country our present water use practices must be changed for the water conservation and water quality maintenance.

Climate change and its effect on water: Scientists predict that the climate change may affect Pakistan water scenario. The river Indus in Pakistan largely depends on the glaciers of the western Himalayas as a reservoir. Scientists believe that owing to significant change in temperature the western glaciers are likely to be effected. Glacier melting in the Himalayas is projected to increase flooding and will affect water resources within the next two to three decades. The agriculture productivity is also being affected due to changes in land and water regimes. The over all effect will thus be on all natural resources including water, industrialization, and economic development of the country.

2. Conclusion

From the ongoing research activities on water it can be concluded that in Pakistan there is a significant awareness about the problems associated with water. Water research both at the academia and the government research institutions have a strong data base for various pollutant due to extensive monitoring programmes. High level of microorganisms and toxic chemicals make the situation from bad to worse. It is very essential to mitigate the problem. In developing countries like Pakistan the financial constraints and expertise often make the use of Hi-tech difficult. The real challenge before the scientists is to provide a low cost technology which can be used by a common man even in rural areas of the country which contains about 60 % of the total population. Thus a political-will needs to be developed in the society and the government to combat this issue. The R & D activities needs to be developed for the capacity building of the institutions engaged in water research A strong University – Industry interaction programme can also provide a solution to the water issue in Pakistan.

3. Acknowledgement

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4. References

[1] Report compiled and published by: Freshwater & Toxics Programme, WWF – Pakistan, 2007 – Pakistan, Ferozepur Road, Lahore – 54600, Pakistan.

[2] M.A. Kahlown, A. Raoof, M. Zubair, W.D. Kemper, *Water use efficiency and economic feasibility of growing rice and wheat with sprinkler irrigation in the Indus Basin of Pakistan,* Int. J. Agr. Water Manage., 87, 3, 292-298, 2007.

[3] M.A. Kahlown and W.D. Kemper, *Reducing water losses from channels\ using linings: Costs and benefits in Pakistan,* Int. J. Agr. Water Manage., 74, 1, 77-85, 2005.

[4] H. A. Randhawa, FAO Corporate Repository, Regional Office of Asia Pacific, *Water development for irrigated agriculture in Pakistan: past trends, returns and future requirements,* Proceeding of the Regional Consultation, Bangkok, Thailand, October 2001.

[5] Proceedings of the *First Regional Workshop on Water Demand Management*, NCEAC, University of Sindh, Pakistan (www.ceacsu.edu.pk), 27-28, August 2008 (in Press).

[6] The World Bank "*Pakistan Water Resources Assistance Strategy*", Nov. 14, 2005.

[7] Education for Environment and Biodiversity in Pakistan, www.edu.iucnp.org.

[8] M.N. Bhutta, *Vision on water for food and agriculture: Pakistan's perspective. South Asia* Regional meeting on water for Food and Agriculture Development. New Delhi, 1999.

[9] Pakistan Water Partnership. Framework for action for achieving the Pakistan Water Vision 2025. Islamabad, Pakistan, 2000.

[10] K. Ahmed, "*Surface Water of Pakistan* ", J. Env. Science Technology and Development, Vol. 9 -11, 2007 PCST, Islamabad, Pakistan.

[11] Ahsan I. Siddiqui, Ph.D.Thesis, University of Sindh, Pakistan, 2006.

[12] K Ahmed, *Toxic elements in Drinking water of Pakistan*, Jour. Chem. Soc. Pak. , Vol. 29, 6, 591, 2007.

[13] R. Nickson, J.M. McArthur, B. Shrestha, T.O. Kyaw-Myint and D. Lowry *Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan.* Applied Geochemistry, Vol. 20, no. 1 ; p. 55-68, 2005.

[14] M. A. Tahir, *Assessment of Arsenic and ther health Significant Water Quality Parameters in Groundwater of Northern Punjab* Ph.D. thesis, Bahauddin Zakariya University, Multan, Pakistan, 2004.

[15] Pakistan Council of Research in Water Resources, House Nos. 3 and 5, Street No. 17, F-6/2, Islamabad, Pakistan. www.pcrwr.gov.pk.

[16] M. Ahmad, M.Y. Kalim and M.I.A. Khan, *Survey of Nitrates in Drinking Water,* Pak. Jour. Chem. Soc. Vol. 25, 1, 2003.

[17] S.K. Alvi, F.A. Khan, I.U. Siddiqui, T.H. Usmani and S.N. Mahmood, *Nitrate / Nitrite contamination in groundwater of Karachi,* Jour. Chem. Soc. Pak. , Vol. 27, 5, 2005.

[18] K. Ahmed and T. Basher, *Nitrate in the Drinking water of southern Punjab,* The Nucleus, 36, 3-4, 1999.

[19] N. Imtiaz, T. Aftab, Z.Iqbal, M. Rasi and A. Hussain, *Nitrate Burden in Drinking water of Northern Punjab, Pakistan,* Jour. Chem. Soc. Pak, Vol. 26, 4, 2004.

[20] M.T. Shah, and S. Danishwar, *Potential fluoride contamination in drinking water of Naranji are NWFP, Pakistan,* Environ.Geochem. Health, 25, 475, 2003.

[21] T. Rafique, S. Naseem, M.I. Bhanger and T.H. Usmani, *Fluoride ion contamination in ground water of Mithi sub-district, the Thar desert, Pakistan,* Environ. Geol., 2007 (in Press) DOI 10.1007/s00254-007-1167-y available on-line.

[22] T. Rafique Ph.D. Thesis, University of Sindh, Pakistan (2008).

[23] R. Hafeez, L. Khan and C. Inayatullah, *Biological indicators for monitoring water pollution,* Pak. J. Agric. Res. , Vol. 16 No.2, 46, 2000.

[24] A. Yilmaz, S. Memon and M. Yilmaz, *Synthesis and study of allosteric effects on extraction behavior of novel calixarene – based dichromate ions receptors,* Tetrahedron, 58, 7735, 2002.

[25] A. Karakucuk, E. Kocabas, A.K. Sirit, Shahabuddin Memon, M. Yilmaz and D.M. Roundhill, *Polymer supported calyx {4) arene Schiff bases: A novel chelating resin for* Hg^{2+} *and dichromate anions,* J. Macromol. Sci., 42, 691, 2005.

[26] S. Memon, M. Tabakci, D.M. Roundhill and M. Yilmaz, *Synthesis and evaluationof the Cr(VI) extraction ability of amino/ nitrile calix {4] arene immobilized onto a polymeric backbone,* React. Funct. Polym. , 66, 1342, 2006

[27] National Center of Excellence in Analytical Chemistry, Jamshoro, Pakistan, www.ceacsu.edu.pk

[28] S.I.H. Naqvi, M.I. Bhanger and S.M. Hasany, *Zn(II) ions removal from aqueous solution by Karachi beach sand, a mixed crystal systems,* Sep. Puri. Technol., 61, 153-160, 2008.

[29] S.I.H. Naqvi, M.I. Bhanger, S.W. Shah and S.M. Hasany, *Exploitation of Beach Sand as a Low Cost Sorbent for the Removal of Pb(II) ions from Aqueous Solution,* Sep. Sci. Technol. 41(3), 531–547, 2006

[30] S.Q. Memon, Najma Memon, S.W. Shah, M.Y. Khuhawar and M.I. Bhanger, *Sawdust – a Green and Economical sorbent for the Removal of Cd(II) ions* , Journal of Hazardous Material, B139 116-121, 2007.

[31] Saima Q. Memon, M.I. Bhanger and M.Y. Khuhawar, *Preceoncentration and separation of Cr(III) and Cr(IV) using sawdust as a sorbent* ", Anal. Bioanal. Chemi., 383, 4, 619 - 624, 2005

[32] Mubeena Akhter, Moosa Hasany, M.I. Bhanger and Shahid Iqbal, *Low Cost Sorbents for the Removal of Methyl parathion Pesticide from Aqueous Solutions,* Chemosphere, 66, 1829 – 1838, 2007.

[33]. Mubeena Akhter, S.M. Hasany, M.I. Bhanger and Shahid Iqbal, *Sorption Potential of Moringa oleifera pods for the removal of organic pollutants from aqueous solutions,* J. Hazard. Mater., 141, 546 – 556, 2007.

[34] *Quality Drinking Water Standards for Pakistan*, Government of Pakistan, Ministry of Health, Health Services Academy, Islamabad, December 2006

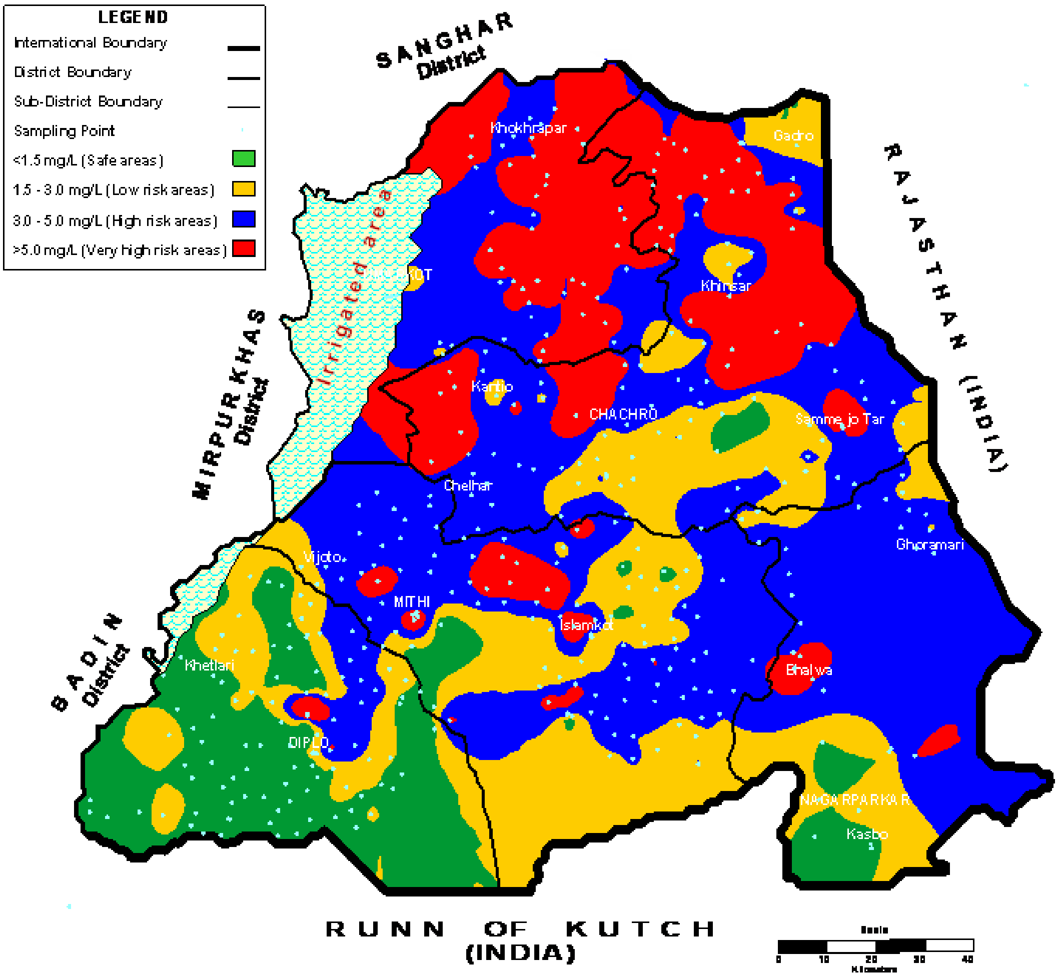

Fig. 1. Map of fluoride ion distribution in the groundwater of Thar desert, Pakistan [22]

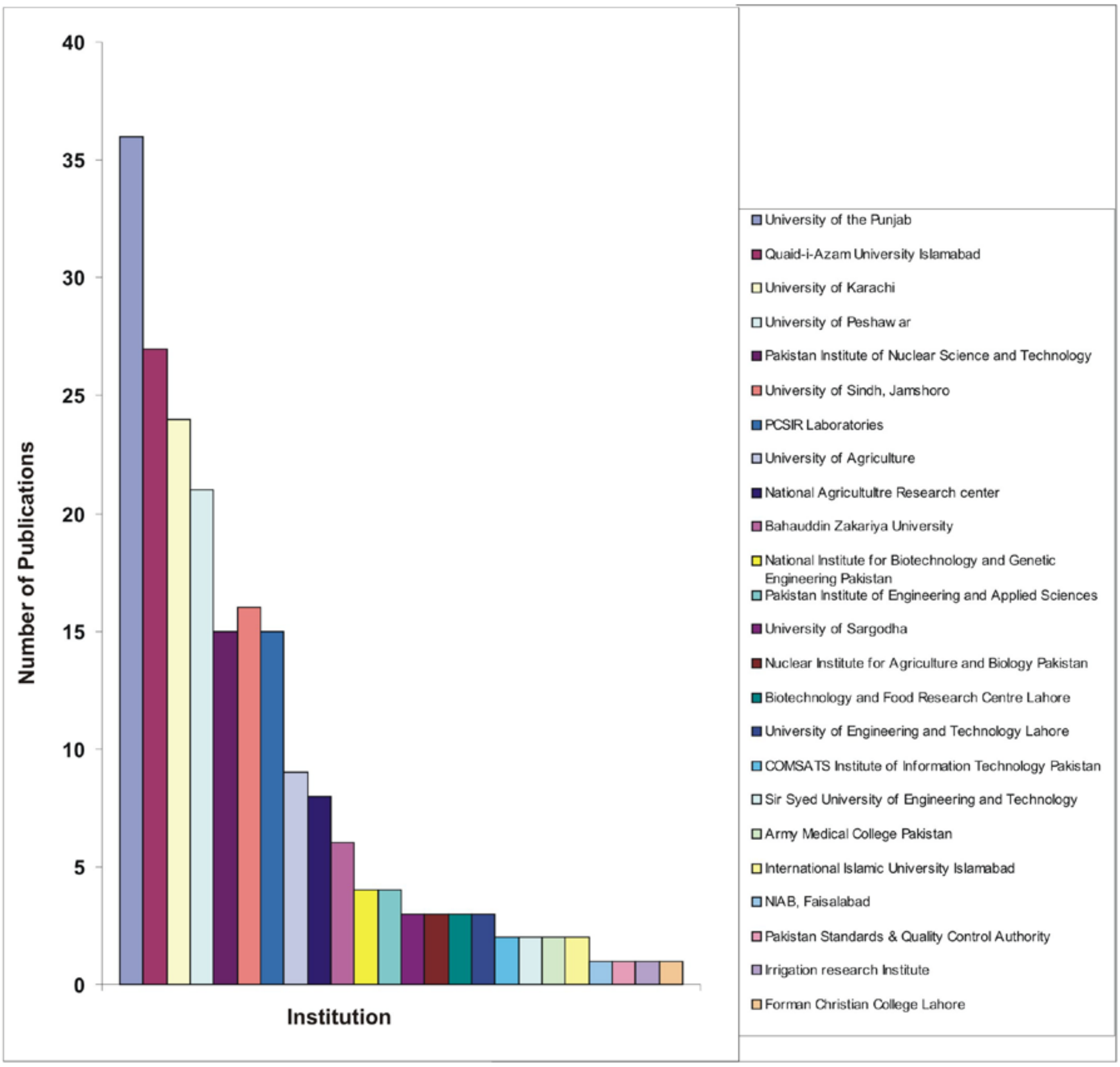

Fig. 2. Number of publication in Pakistan on water pollution assessments during last decade (*Source* : Scopus)

Table - 1. Standards for Quality Drinking Water in Pakistan [34]

PROPERTIES / PARAMETERS	**GUIDELINE / STANDARD VALUES FOR PAKISTAN**	**WHO** STANDARD
Physical		
Colour	≤15 TCU	≤15 TCU
Taste	Non objectionable/Acceptable	Non objectionable/Acceptable
Odour	Non objectionable/Acceptable	Non objectionable/Acceptable
Turbidity	‹ 5 NTU	‹ 5 NTU
Total hardness as $CaCO_3$	< 500 mg/L	---
TDS	‹ 1000	‹ 1000
pH	6.5 – 8.5	6.5 – 8.5
Chemical		
Essential Inorganic	***mg/L***	***mg/L***
Aluminium (Al) mg/L	≤0.2	0.2
Antimony (Sb)	≤0.005 (P)	0.02
Arsenic (As)	≤ 0.05 (P)	0.01
Barium (Ba)	≤2.0(P)	0.7
Boron (B)	0.3 – 0.5 (P)	0.5 (T)
Cadmium (Cd)	0.003 – 0.01	0.003
Chloride (Cl)	≤400	250
Chromium (Cr)	≤0.05	0.05
Copper (Cu)	1 – 2	2
Toxic Inorganic	***mg/L***	***mg/L***
Cyanide (CN)	0.05 – 0.1(P)	0.07
Fluoride (F)*	≤1.5	1.5
Lead (Pb)	≤0.05	0.01
Manganese (Mn)	≤ 0.5	0.5
Mercury (Hg)	≤0.001	0.001
Nickel (Ni)	≤0.02	0.02
Nitrate (NO_3)*	≤50	50
Nitrite (NO_2)*	≤3 (P)	3
Selenium (Se)	0.01(P)	0.01
Residual chlorine	0.2-0.5 at consumer end 0.5-1.5 at source	--
Zinc (Zn)	2.0 – 5.0	3
* indicates priority health related inorganic constituents which need regular monitoring. P indicates that the limits given are provisional because the authenticated data is not available for the conformation of human health related effects with these constituents. T indicate total permissible amount		
Organic		
Pesticides mg/L		PSQCA No. 4639-2004, Page No. 4 Table No. 3 Serial No. 20-58 may be consulted.***
Phenolic compounds (as Phenols) mg/L		≤ 0.002

PROPERTIES / PARAME TERS	**GUIDELINE / STANDARD VALUES FOR PAKISTAN**	**WHO** STANDARD
Polynuclear aromatic hydrocarbons (as PAH) g/L		0.01 (By GC/MS method)
Bacterial		
Escherechia coli Non-chlorinated water	0 – 3 MPN (only in 5 % sample of water)	
Escherechia coli	Must not be detectable in 100 ml sample	
Radioactive		
Alpha Emitters bq/L or pCi	1 pCi	--
Beta emitters		

*** PSQCA: Pakistan Standards Quality Control Authority

Table – 2 Pakistan National Environmental Quality Standards for Municipal and Liquid Industrial Effluents (mg/L, unless defined) *Source: EPA Pakistan*

No.	Parameter	Existing Standards	Revised Standards		
			Into Inland Water	Into Sewage Treatment	Into Sea[6]
1	Temperature or Temperature increase	40°C	=< 3°C	=< 3° C	=< 3° C
2	pH value	6-10 pH	6-9	6-9	6-9
3	5-days Biochemical Oxygen Demand (BOD_1) at 20°C	80mg/l	80	250	80**
4	Chemical Oxygen Demand (COD)[1]	150	150	400	400
5	Total suspended solids	150	200	400	200
6	Total dissolved solids	3500	3500	3500	3500
7	Grease and oil	10	10	10	10
8	Phenolic compounds (as phenol)	0.1	0.1	0.3	0.3
9	Chloride (as Cl)	1000	1000	1000	SC
10	Fluoride (as F)	20	10	10	10
11	Cyanide (as CN) total	2	1.0	1.0	1.0
12	An-ionic detergents[2] (as MBAS)	20	20	20	20
13	Sulphate (SO_4)	600	600	1000	SC
14	Sulphide (S)	1.0	1.0	1.0	1.0
15	Ammonia (NH_3)	40	40	40	40
16	Pesticides, herbicides, fungicides and insecticides[3]	0.15	0.15	0.15	0.15
17	Cadmium	0.1	0.1	0.1	0.1
18	Chromium (trivalent and hexavalent)	1.0	1.0	1.0	1.0
19	Copper	1.0	1.0	1.0	1.0
20	Lead	0.5	0.5	0.5	0.5
21	Mercuy	0.01	0.01	0.01	0.01
22	Selenium	0.5	0.5	0.5	0.5
23	Nickel	1.0	1.0	1.0	1.0
24	Silver	1.0	1.0	1.0	1.0
25	Total toxic metals	2.0	2.0	2.0	2.0
26	Zinc	5.0	5.0	5.0	5.0
27	Arsenic	1.0	1.0	1.0	1.0
28	Barium	1.5	1.5	1.5	1.5
29	Iron	2.0	8.0	8.0	8.0
30	Manganese	1.5	1.5	1.5	1.5
31	Boron	6.0	6.0	6.0	6.0
32	Chlorine	1.0	1.0	1.0	1.0