Analysis of Groundwater Quality and its Impact on Human Health: A Review

Mr. Taswar Abbas*

Abstract

Drinking water contaminations with pathogenic microorganism are one of the extreme threats to human health, especially in developing countries. The present study reveals the current condition of drinking water quality, presence of pathogenic microorganisms, physiochemical properties and its effect on public health in Punjab Province, Pakistan. The prime objective of this study is to examine drinking water contamination in various areas of Punjab province. Due to alarming growth of population, prompt industrialization, improper monument of sewage disposal the water quality is being deteriorated. The studies carried out in Punjab province clearly indicate that in maximum of the areas drinking water quality is now distorted to polluted water. Drinking water source such as ground water and surface water are infected with coliforms, poisonous metals and pesticides in the province. This extreme environmental problem leads to many diseases as well as death in the province. The quality standards for drinking water set by WHO are frequently ignored. The primary sources which contribute to deterioration of water quality includes such as, improper disposal of municipal waste, industrial effluents, and indiscriminate utilization of agrochemicals in agriculture. Major diseases associated with contaminated drinking water in Punjab are gastroenteritis, hepatitis, typhoid; diarrhoea, giardiasis intestinal worms, cryptosporidium infections, and infant deaths are caused by waterborne diarrhoea. There is an urgent need for mitigation steps to minimize further deterioration of water quality and safeguard the population from widespread waterborne diseases. It is dire need of hour

* Department of Earth Sciences, University of Sargodha, Sargodha, Pakistan.

to strictly implement various polices and guideline set by government and WHO for clean drinking water.

Keywords

Water Quality, Diseases, Punjab, Pakistan

Introduction

Water is essential instinctive resource for life on planet earth. Its covers 70% part of the earth surface and only less than 3% of this is fresh water. The measure of freshwater accessible for mankind utilization is just 0.01% while the remaining is stored in glacier and ice (Ahmad et al., 2014). The population of world is increasing day by day and civilization is also getting flourished. As the population is increasing, clean and fresh water demand has increased exponentially not only for household utilization but also for the development of industry and agriculture (Gilani et al., 2013). Access to clean drinking water can guarantee a healthy life. Water quality and usage plays a vital role in development of the economic condition of the world (Chennakrishnan et al., 2008). By the observation of last 10-15 years, it has been discovered that ground water has become contaminated by physical, biological and chemicals conditions. Directly or indirectly, human activities are contributing at large to deterioration of water quality (Dix, 1981). Naturally groundwater is supposed to have very less number of pollutants but it may vary from area to area (Gajendran el al., 2013). The groundwater quality depends upon the source rock or aquifer chemistry (Wuana & Okieimen, 2011). Anthropogenic exercises generate different unsafe substance with the water which brings about broad water-connected sickness (Soomro et al., 2011). Globally all nations are concerned about the impact of polluted water since waterborne diseases are significant reasons for deaths (Clasen et al., 2007: WHO, 2010). Uncontaminated drinking water is necessary for the good health and plays an important role in infant survival and wellbeing (Anderson et al., 2002: Fewtrell et al., 2005: Ross et al., 1988: Vidyasagar, 2007). The circumstances are more terrible in developing countries where the majority of the individuals use polluted water with undesirable degrees of pollutants like synthetic concoctions, pathogenic organisms and suspended solids (Amin

et al., 2012). The United nation (UN) has evaluated that around 2.5 billion individuals in developing countries have no access to appropriate fresh water and more than 780 million have no access to clean drinking water (UNICEF and WHO, 2012).

In Pakistan contaminated water quality is the major environmental and wellbeing associated matter. Drinking water from the both sources groundwater as well as surface water in country is contaminated with different harmful compounds and microorganisms (Azizullah et al., 2011). The poor livelihood conditions with some negligence have polluted drinkable water (Rasheed et al., 2009). Water treatment plans are installed only in few urban centres: however few of these are not appropriately working and leave traces of microbial defilement unobserved. A survey for clean and safe drinking water conducted by government indicates that only 56% population in Country approaches clean and safe drinking water, yet 44% of population in the rural areas have been deprived from clean water (Farooq et al., 2008). Different studies indicated that about 70% of country population has no access to safe drinkable water (Amin et al., 2012). This scenario results in occupancy of approximately 20-40% of hospitals beds in Pakistan by patients experiencing water associated diseases such as, typhoid, hepatitis, dysentery, cholera and diarrhoea and 33% of all deaths in country are related to waterborne diseases (Pak-SECA, 2006).

In Punjab province water quality monitoring test were completed in 12 major districts and results revealed that arsenic (Ar) metal and microbial was significant pollution observed in all areas. In 45% of samples of Kasur area tested positive for microorganisms contaminations. Another 88%, 100%, 94%, 64%, 100% and 73% of drinking water tests of Bahawalpur, Kasur, Multan, Gujranwala, Lahore and Sheikhupura were contaminated with arsenic respectively. Total dissolved solid were found over as for as permissible in Sheikhupura, Faisalabad, Sargodha Rawalpindi and Kasur (Soomro et al., 2011). The physiochemical analysis of collected ground water samples from different rural areas of Punjab disclosed that water quality was not fit for drinking purpose and higher level of toxic metals (Cl, No3, So4, Fe, Mn,

and Pb) were found as compared to permissible limits (Shakoor, et al., 2015).

Numerous individual investigations reported that drinking water in Punjab province had microbial and physiochemical pollutants over the permissible limits; nonetheless, in the past quantitative statistics on this issue have not been methodically accumulated. The main objective of this article is to sum up and feature the drinking water contamination in various areas of Punjab province, Pakistan with subsequent health risk. This article will provide deep insight for the governmental specialist health cares and administrated institutions to applicable investigations and develop new strategies to preserve supplementary contamination of water quality and make sure safe drinking water to the people of country.

Literature Review

Drinkable water quality and its effects in Punjab were analysed by Aziz (2005). Results of this study highlighted that the diarrheal disease found second in rank amongst top fifteen infectious diseases in the children with their age of less than five year, this is a clearly indicative of the faecal pollution of drinking-water supplies. Kahlown et al. (2007) described that fifth report of national water quality monitoring (2005-2006), the ground water samples from 16 locations were collected and none of them were found safe for drinking purpose. Almost 25% and 56% samples were found polluted with E. coli and coliforms respectively. Additionally, 94% Arsenic (As), 19% manganese (Mn), 44% (Fe), 19% turbidity and 6% calcium water samples were also found contaminated.

Another study was carried out to evaluate the groundwater quality of Kalalanwala area in Kasur district. The results of the study indicated the high level of contamination form selective parameters. The comparison was made between aquifer level depth and at deeper groundwater sample. The deeper aquifer was free from the contamination of fluoride while near the surface its concentration was found high. The study findings showed the high concentrations of SO4, F and As in ground water as well as in rain water (Farooqi et al., 2007).

The physiochemical investigation of drinking water was completed to assess the drinkable water quality of Sialkot city. On the basis of Cluster Analysis (CA) all sites were divided into four zones based on their physiochemical properties, similarities and dissimilarities. Zone one results showed the higher concentration of EC, TDS, Cl, So4, total hardness, Fe, Pb, and turbidity. Discriminate Analysis (DA) and Factor Analysis (FA) revealed important variables including Total hardness, TDS, pH, SO3, NO3, SO4, Cl, Alkalinity, Fluoride, Fe, EC, Pb and turbidity which are the major contributing factors for water quality and water chemistry. The results exposed that the groundwater quality in the study area is contaminated and cannot be considered as good quality as it is highly turbid (57%) with high level of Fe, Zn and Pb which were above WHO recommended values (Ullah et al., 2009).

Ground water quality has been assessed by Hayder et al. (2009) in southern Lahore and physiochemical and bacteriological parameters with two set of water sample collected before and after monsoon for statistical results. The study results demonstrate that bacteriological and physiochemical water quality of samples was satisfactory as 50% to 62.5% before monsoon that rose to 75% after the monsoon. The leaking of water from main lines and cross connection between water supply lines and sewer were major reasons for contamination. Physiochemical analysis of ground water samples collected from the urban areas of Faisalabad disclosed that the water quality is very poor for drinking purpose. High level of TDS, alkalinity, sulphate, and chloride were observed in many samples. The overall ground water quality of Faisalabad urban areas was contaminated with sewerage water (Farid et al., 2012).

Khattak et al. (2012) have examined the groundwater quality near the Hudiara industrial drain channel Lahore, for irrigation and drinking purpose. Overall, drinking water quality of collected water samples from various locations were exposed acceptable and complimentary from contamination of anthropogenic origin. Only 21% samples were imperceptibly appropriate which can be utilized for irrigation alongside certain amendments and adopting extraordinary administration practices whereas, 79% samples were polluted and cannot be used for irrigation

and drinking purpose. A study was documented on Bahawalpur city to assess the physiochemical properties of ground water and results disclosed that because of the low quality water, the waterborne diseases like cholera, typhoid, diarrhoea and so on were regular in study areas, especially in Islamic colony about 36% population have been confronting severe diseases. Whereas, the seriousness of waterborne diseases among the inhabitants of Satellite town (18.1%) and Shahdrah (22.1%) were relatively less as compared to Islamic colony.

Drinking water quality of Rustic area of Gujrat was assessed by Qasim et al. (2014). The primary motive for the assessment was to contemplate remedial issue by the unhygienic drinking water. The investigation presumed that cholera 4.2%, dysentery 6.4%, typhoid 10.9%, gastro 21.5%, goiter 6%, hepatitis A 5.3%, hepatitis E 10.6%, diarrhoea 6.8%, acute respiratory 14.3% and malaria 14% were found in the residence of district Gujrat rural areas. Water quality assessment was completed to get to the arsenic level in drinking water of Sheikhupura. Study finding indicated that the proximity of arsenic with variable range over the admissible degrees of WHO (10 ppb) represents a developing danger to human health and 17% had respiratory diseases, 14% of them had liver issue, 5% had lose weight, 11% had reduced bulk of limbs, 12% of them had skin infectivity, and 27 % of respondents grumbled about blood pressure, 8% diabetes, and 22% had muscular suffering. It is clear from the consequences of the examination that the quality of the water in Sheikhupura area isn't acceptable and consequently can cause problems for the public health and general environmental issues (Abbas & Cheema, 2015).

Faisalabad is known as contaminated industrial city because of the inadequate facilities. 225 water samples were collected and Logit Model (LM) was applied on socioeconomic factor as determinants for safe drinking water utilization. Result identified adverse effect and all samples were polluted with organisms' like total coliform, total plate count and E. coli (0157), just as indicated high values of TDS, hardness and turbidity. Water sample collected for physiochemical analysis from Sargodha city through randomly, chemical and physical parameters were assessed by using Atomic Absorption Spectrometer (ASS). The

compared result with WHO highlight the high level of concentration of all parameters except pH and Ca in the study area. Consequently, it is revealed that the ground water quality of assessed area is not acceptable for drinking purpose (Riaz et al., (2016). Another study carried out the physio-chemical investigation of ground water and its brunt on community healthiness in Sargodha (Riaz et al., 2017). The study results showed that zone I was the most affected area from water related diseases. Survey analysis presented that 43.49% people were suffering from waterborne diseases while the situation in other zones was comparatively better as 29.68%, 26.33% and 25.83% people were affected in zone II, III, IV respectively.

The focused study was designed to assess the physiochemical concentration in drinking water near the Salt Range by taking samples from Khewra and Pind Dadan Khan. The study results disclosed that the higher level of EC and TDS, Sulfate, Iron, Chlorides, and Chromium, were found 48%, 24%, 16%, 10%, 30%, and 54% respectively. The above levels of some parameters were indicating the polluted and contaminated water condition in Salt Range area and very risky for health. In study area some common diseases exist due to contamination of drinking water with toxic metals viral hepatitis, gastrointestinal problem, diarrhoea, hypertension and some urinary problems. Without proper treatment the study area water cannot be used for drinking purpose (Batool et al., 2018).

Abbas et al., (2018) investigate the water quality with reference to municipal solid waste in Jhang city. The study concluded that EC found high 90%, TDS 75%, Hardness 60%, Chloride 35%, Calcium 30% and alkalinity 25% respectively. The study finding showed that water quality nears the dump site was not fit for drinking Purpose. Rehman et al. (2019) evaluated the groundwater quality of Sargodha city and its suitability for domestic and irrigation purpose. Correlation coefficient matrices were calculated among ten water quality parameters namely calcium, sodium, potassium, magnesium, copper, iron, nitrates, sulphates, chloride and E.C. Salinity hazard, Kelly's ratio and Sodium adsorption ratio were calculated to classify the groundwater for irrigation

purpose. Results indicate that groundwater cannot be used as potable; however it can be utilized for irrigation.

Investigation of the bacteriological and physicochemical characteristics of drinking water samples and their sources in Mianwali city was carried out in 115 Water Supply Schemes (WSS). One of the trusted methods "Rapid Microbiological Testing Method" was utilized to assess the bacteriological contamination of water samples. In addition, study results indicated that 71% of tap water samples were found contaminated as compared to 41% from WSS. Thus, WSS of Mianwali was not trusted regarding safe drinking water since they are accountable for 30% bacteriological contamination (Akhtar et al., 2019).

An investigation of groundwater quality was done on Bhalwal city and on-going examination identified the higher concentrations of TDS (69.05%), EC (83.3%), and K (61.9%) in water and Tehsile Head Quarter (THQ) reports verified the results by showing patients data. Hospital reports showed the 181, 522, 211 and 16 patients of asthma, cardiovascular, diarrhoea and kidney stone monthly in 2017, respectively (Farooq et al., 2019). The assessment of groundwater quality is essential to estimate the suitability for drinking purpose and good health. The attempt has been made to evaluate the groundwater quality of Sahiwal and Sheikhupura. Study results were indicating the high concentration of fluoride, iron, nickel, cadmium and microbiological in Sheikhupura while bicarbonate and electronic conductivity in Sahiwal water samples (Deeba et al., 2019).

Human Health Impact

Due to the poor treatment, monitoring and sanitation network drinking water quality is of fall part in Punjab province. The existence of toxic synthetics, metals and microorganisms in water causes unfavourable impact on human health. Fecal contamination is playing a vital role and individuals have been experiencing waterborne diseases. In rural and urban areas of province waterborne diseases like, diarrhoea, typhoid, hepatitis, and cholera are efficiently revealed. In any case, it is very difficult to appropriately measure the threat of diseases. Smith (1999) documented the diseases and poor record maintenance in

healthcare focuses and emergency clinics identified with diseases brought about by the polluted water.

A few investigations have declared health related issues because of polluted drinking water in province especially in big cities. For Instance, the high values of NO3 causing blue baby syndrome in bottle feed babies (Daud et al., 2017). Every day normally the intake of potassium (K) by adults was noted to be under 0.1% through water and huge amount of K is significant, equivalent to different components for appropriate functioning body. Diseases for example, kidney diseases, heart issue, hypertension, asthma and muscle weakness might be caused by K level diminishing in blood and high level may cause improper metabolism of protein, rapid heartbeat and reduced renal function (Marijic, 2001). Reduction of Na in body may cause weakness, mental unresponsiveness, low blood pressure and sadness while high level can cause kidney issue, sickness, migraines, brain stroke, stomach issue and hypertension. Calcium and magnesium cations inadequacy might be brought cardiovascular diseases. The essential and significant component for haemoglobin and myoglobin and for various different enzymes is iron (Fe). The more elevated level of Iron in body likewise causes numerous health such as central nervous system, weakening of cardiovascular tissue, liver blood issues, diarrhoea and vomiting (Daud et al., 2017; Goldhaber, 2003).

Dental fluorosis was additionally found in numerous areas for example, Rawalpindi, Pattoki and Kasur (Aziz, 2002). Effluents originating from the tanneries polluted the ground water in Kasur District and caused skin and stomach issues. Microorganisms were found in water including numerous bacterial, viral and protozoan specialists' causing 2.5 million deaths from endemic diarrheal infection every year. The major health issues were accounted for as diarrhoea (47%- 59%), gastroenteritis (40%), hepatitis A (32 % to 38%) hepatitis B (16%-19%), hepatitis C (6%to 7%), and dysentery (28%-35%) by respondents (Khan et al., 2015). Waterborne diseases such as, dysentery, giardiasis, typhoid, cryptosporidiosis, hepatitis and worm infection are responsible for 80% of all diseases and for 33% death (Daud et al., 2017). Contamination of water in Punjab province is the major reasons for this including sewerage

system, untreated disposal of industrial waste, domestic water and damaged municipal water supply lines. There is also a major reason that people have no idea about the water quality and water pollution. They should be educated to know what kind of water they have been in to avoid waterborne diseases in future. Intake of polluted drinking water is not only the harmful for health but also lose to the country development and money. The government should pay more attention to resolve this issue to save the lives of the people and development of the country from destruction.

Conclusion

Amongst all the essential elements of human life, water is the most significant, to the extent of being inevitable for the continuity of life on earth. A society can be termed healthy only when its members have clean water available for drinking. It's a sad phenomenon all over the world that the water available for living beings is impure for a large number of people. The data has been collected from various sources. During the data collection, it was revealed that there isn't much research already available about the topic. The ground water in the Province Punjab is found exceptionally polluted and risky for drinking purposes as, it, by no means, meets the standards set by WHO. This detailed review study has been documented in Punjab province on the quality of drinking water which reveals that the primary cause behind the awful contamination of water is the poor sanitation and sewage system. The situation is further worsened when the industrial and domestic waste is diffused in the water and this waste and untreated effluent become a secondary source of water contamination. The diffusion of physiochemical and microbial elements makes the water unhealthy and misfit for use but still when this water is used it carries a host of diseases and thus water borne diseases are easily transferred to the living beings because there are no treatment plants for purifying of the impurities of water before it is used. For the improvement of Public health, the situation can be improved. The waterborne diseases can be controlled with an improvement in the quality of water. If the water is disposed safely, its diffusion with drinking water can be prevented. The sanitation facilities should be upgraded and this will also lead to keep the drinking water safe from

contamination. The study reveals that drinking water is contaminated from various sources and it should be considered a hazard to health as well as environment.

Recommendations

The initial steps to be followed towards the betterment in the case of contaminated drinking water which in turn will improve the quality of drinking water. In the first place the quality of water must be monitored. Before the water is supplied for use, appropriate filtration process must be ensured. WASA has a significantly important role to monitor and check with regular short intervals the conditions of water supply pipelines. The damaged or outworn pipelines should be replaced with new ones. A great way to keep the water safe from cross contamination is to ensure a safe distance between sewerage lines and water supply lines. They should be distant enough to save the mixing of pure water with contaminated water from sewerage pipelines, in case of any sudden rupturing of pipelines. Industry's role in this regard is equally important. Industrial waste should be properly treated according to prescribed standards before it is disposed-off into water. Efficient plants should be installed for municipal waste water for accumulation and treatment in big cities. State level legislation should be done to ensure the supply of healthy water for the use of living beings the law should be implemented strictly without any compromise on the quality of water. A campaign should be launched, promoting and creating awareness among masses about water contamination and the diseases caused by it. People from all strata of life should me motivated to actively participate in this awareness campaign including mosques, educational institutes, print and electronic media etc. There is a need to revise the policies about the quality of water, so policies about improving the quality of drinking water should be improved and for this purpose additional financial budget should be allocated. The researchers must come up with better and new methods of treatment and purification of water. They should show diligence in laboratory work which can be very helpful to improve the quality of water and diminish the risks of water contamination. It is recommended that the current research will deliver healthy information

about extremely contaminated parts and that will be more useful for the prospect preparation.

References

Abbas, M., & Cheema, K. J. (2015). Arsenic levels in drinking water and associated health risk in District Sheikhupura, *Pakistan. Journal of Animal and Plant Sciences*, 25(3), 719-724.

Abbas, T., Ullah, F. M., Riaz, O., Shehzad, T. (2018). Impact of Municipal Solid Waste on Groundwater Quality in Jhang City Punjab, Pakistan. *J. Bio. & Env. Sci.* 12(1), 134 141.

Ahmed, T., Pervez, A., Mehtab, M., Sherwani, S. K. (2014) Assessment of drinking water quality and its potential health impacts in academic institutions of Abbottabad (Pakistan). Desalin Water Treat. doi:10. 1080/19443994.2014.890133.

Akhtar, S., Fatima, R., Soomro, Z. A., Hussain, M., Ahmad, S. R., & Ramzan, H. S. (2019). Bacteriological quality assessment of water supply schemes (WSS) of Mianwali, Punjab, Pakistan. *Environmental Earth Sciences*, 78(15), 458.

Amin, R., Ali, S. S., Anwar, Z., Khattak, J. Z. K. (2012). Microbial analysis of drinking water and water distribution system in new urban Peshawar. *Curr Res J Bio Sci* 4, 731-737.

Anderson, B. A., Romani, J. H., & Phillips, H. E. (2002). Environment, access to health care, and other factors affecting infant and child survival among the African and Colored populations of South Africa, 1989-94. *Population and Environment*, 23, 349-64.

Aziz, J. A. (2002). National water quality strategy. Report submitted to The Asian Development Bank as part of water resources strategy study, ADB, TA, 3130.

Aziz, J. A. (2005). Management of source and drinking-water quality in Pakistan. *J. of East Mediterr Health*, 11, 1087–1098.

Azizullah, A., Khattak, M. N. Richter, P., Häder, D. (2011) Water pollution in Pakistan and its impact on public health—a review. Environ Int 37, 479–497.

Batool, A., Aziz, S., & Imad, S. (2018). Physico-chemical quality of drinking water and human health: a study of salt range Pakistan. *Int J Hydro*, 2(6), 668-677.

Chennakrishnan, C., Manju, T., Stephren, A., & Raveen, R. (2008). Water Quality status of three vulnerable freshwater Lakes of Suburban Chennai. India: Delhi. *Indian Journal of Public Health*, 40(2).

Clasen, T., Schmidt, W., Rabie, T., Roberts, I., Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. *British Medical Journal*, 1-10.

Daud, M. K., Nafees, M., Ali, S., Rizwan, M., Bajwa, R. A., Shakoor, M. B., & Malook, I. (2017). Drinking water quality status and contamination in Pakistan. *BioMed research international.*

Deeba, F., Abbas, N., Butt, M., & Irfan, M. (2019). Ground water quality of selected areas of Punjab and Sind Provinces, Pakistan: Chemical and microbiological aspects. *Chemistry International*, 5(4), 241-246.

Dix, H. M. (1981). Environmental Pollution. John Wiley. Chichester, 121-124.

Farid, S., Baloch, M. K., & Ahmad, S. A. (2012). Water pollution: major issue in urban areas. *International Journal of Water Resources and Environmental Engineering*. 4:55–65.

Farooq, S., Hashmi, I., Qāḍī, I. A., Qaiser, S., & Rasheed, S. (2008). Monitoring of coliforms and chlorine residual in water distribution network of Rawalpindi. *Pak Environ Monit Assess* 140:339–347.

Farooq, U. M., Batool, S., Riaz, O., Minallah, N. M., Abbas, T., & Tayyab, M. (2019). Assessment of groundwater contamination and its impact on public health in Bhalwal City, Pakistan. *Journal of Biodiversity and Environmental Sciences*. 15(1), 1(11).

Farooqi, A., Masuda, H., & Firdous, N. (2007). Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. *Environmental pollution*, 145(3), 839-849.

Fewtrell, Lorna, Kaufmann, Rachel B., David, K., Wayne, E., Laurence, H. & John, C. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: A systematic review and meta-analysis. *The Lancet Infectious Diseases*, 5, 42-52.

Gajendran, C. Jayapriya, S. Yohannan, D. Victor, O., & Jacob, C. (2013). Assessment of Groundwater Quality in Tirunelveli District, Tamil Nadu, India. *Journal of Environmental Sciences*, 3(6), 1874-1880.

Gilani, S. R., Mahmood, Z., Hussain, M, Baig, Y., Abbas, Z., & Batool, S. (2013). A Study of Drinking Water of Industrial Area of Sheikhupura with Special Concern to Arsenic, Manganese and Chromium. *Pakistan Journal of Engineering & Applied Science*m, 13, 118-126.

Goldhaber, S. B. (2003). Trace element risk assessment: essentiality vs. toxicity. *Regulatory toxicology and pharmacology*, 38(2), 232-242.

Hayder, S., Arshad, M., Aziz, J. A. (2009). Evaluation of Drinking Water Quality in Urban Area of Pakistan; A Case Study of Southern Lahore. *Pak .J. Engg. & Appl. Science*, 5, 16-23.

Kahlown, M. K., Tahir, M, A., & Rasheed, H. (2007). Pakistan Council of Research in Water Resources Ministry of Science and Technology Islamabad. National Water Quality Monitoring Programme Fifth Monitoring Report (2005-06). *Pakistan Council of Research in Water Resources (PCRWR).*

Khan, S. S., Tareen, H., & Jabeen, U. (2015). Quality assessment of drinking water from the different colonies of Quetta city, Pakistan according to WHO Standards. *Biological Forum: An International Journal*, 7, 699–702.

Khattak, M. A., Ahmed, N., Qāḍī, M. A., Izhar, A., Ilyas, S., Chaudhary, M. N., & Waheed, T. (2012). Evaluation of ground water quality for irrigation and drinking purposes of the areas adjacent to Hudiara industrial drain, Lahore, Pakistan. *Pak. J. Agri. Sci*, 49(4), 549-556.

MARIJIC, J. (2001). Voltage and calcium-activated K^+ channels of coronary smooth muscle. Heart physiology and pathophysiology.

Memon, M., Soomro, M. S. Akhtar, M. S. & .Memon, K. S. (2011). Drinking water quality assessment in Southern Sindh (Pakistan). *Environmental Monitoring and Assessment*, 177(1-4), 39–50.

Mohsin, M., Safdar, S., Asghar, F., & Jamal, F. (2013). Assessment of drinking water quality and its impact on residents health in Bahawalpur city. *International Journal of Humanities and Social Science*, 3(15), 114-128.

Nabeela, F., Azizullah, A., Bibi, R., Uzma, S., Murad, W., Shakir, S. K., & Hader, D. P. (2014). Microbial contamination of drinking water- A review. *Environmental Science Pollution Research*, 21, 13929-13942.

Pak-SECA, (2006). Pakistan; strategic country environmental assessment report: rising to the challenges. South Asia environment and social development unit, Islamabad.

PCRWR, (2005). National water quality monitoring programme. Pakistan Council for Research in Water Resources, Islamabad.

Qasim, M., Anees, M. M., & Bashir, A. (2014). Unhygienic water is the cause of water borne disease among villagers: A case of Gujrat-Pakistan. *World Applied Sciences Journal*, 29(12), 1484-1491.

Rasheed, F., Khan, A., Kazmi, S. U. (2009). Bacteriological analysis, antimicrobial susceptibility and detection of 16S RNA gene of Helicobacter pylori by PCR in drinking water samples of earthquake affected areas and other parts of Pakistan. *Mal. J. Microbiol* 5, 123–127

Rehman, F., Cheema, T., Azeem, T., Naseem, A. A., Rehman, F., Riaz, O., Abbas, T., & Rehman, S. U. (2019). Groundwater quality of Sargodha city and its suitability for domestic and irrigation purpose. *Fresenius environmental bulletin*, 28(11), 7695-7700.

Riaz, O., Abbas, T., Minallah, M. N., Rehman, S., & Ullah, F. (2016). Assessment of Ground Water quality: A case Study in Sargodha. City, Pakistan. Sci. Int. 25(5), 4715-4721.

Riaz, O., Abbas, T., Ullah, F.M., Rehman, S., & Khalid, M. (2017). Physio-chemical analysis of ground water and its impact on public health in Sargodha City, Pakistan. *J. Bio. & Env. Sci*., 11(5), 376-384.

Ross, J. A., Rich, M., Molzen, J., & Pensak, M. (1988). Family planning and child survival in one hundred developing countries. New York: Center for Population and Family Health, Columbia University.

Shakoor, M. B., Niazi, N. K., & Bibi, I. (2015). Unraveling health risk and speciation of arsenic from groundwater in rural areas of Punjab, Pakistan. *International Journal of Environmental Research and Public Health*, 12(10), 12371–12390.

Smith, J. (1999). Health Management Information Systems: A handbook for decision makers. McGraw-Hill Education (UK).

Soomro, Z. A., Khokhar, M. I. A., Hussain, W., & Hussain M. (2011). Drinking Water Quality Challenges in Pakistan, World Water Day, pp. 17–28.

Ullah, R., Malik, R. N., & Qadir, A. (2009). Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. *African Journal of Environmental Science and Technology*, 3(12), 429-446.

UNESCO. (2003). Water for people water for life. The United Nations world water development report. United Nations Educational, Scientific and Cultural Organization

UNISEF and WHO. (2012). Progress on drinking water and sanitation update 2012. Accessed from; http://www.unicef.org/media/files/ JMPreport2012.pdf

Vidyasagar, D. (2007). Global minute: Water and health - walking for water and water wars. *Journal of Perinatology*, 27, 56–58.

Wuana, R. A., & Okieimen, F. E. (2011). Heavy metals in contaminated soils: a review of sources, chemistry, risks and best available strategies for remediation. Isrn Ecology.

World Health Organization. (2010). UN-water global annual assessment of sanitation and drinking-water GLAAS): Targeting resources for better results. Geneva: WHO Press.

Zulfiqar, H., Abbas, Q., Raza, A., & Ali, A. (2016). Determinants of safe drinking water in Pakistan: a case study of Faisalabad. *Journal of Global Innovations in Agricultural and Social Sciences*, 4(01), 40-45.