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Performance assessment of water filtration plants in Pakistan

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Abstract

A study was carried out to evaluate the water quality of filtration plants installed at six different places of Cantonment Board Sialkot, Pakistan to suggest and recommend guidelines for their improvement. Water samples from six Treatment plants and their respective twelve connections (two from each treatment plants) were collected before and after treatment. In this way, total samples were collected and tested. Values of these samples before and after treatment were used for comparison with World Health Organization (WHO) guidelines for drinking water standards. Thirty three parameters including physical, chemical and bacteriological were determined for each sample. The results were satisfactory both chemically and bacteriologically according to WHO guidelines for water quality of treatment plants. The results showed that the samples of water were fit, both before and after treatment plant except for water sample of treatment plant No. IV & V (Before treatment). Total and faecal coliform were found in these samples. Various causes of faecal contamination before treatment may be due to leakage of pipelines, operation at tubewells, layout of freshwater pipes parallel or beneath the sewerage pipes or channels. Disinfection of water at source is recommended to deal with the faecal contamination; otherwise there is no need of filtration plant.

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Introduction

Water is blessing of Allah and is very precious resource of this planet as it is an established source of life and civilization. Over other planets and even galaxies, the constituent parts of water are searched as emblem of life. It is well known that human health and survival depends on use of uncontaminated and clean water for drinking and other domestic purposes.

Nature has blessed Pakistan with adequate surface and groundwater resources. Both of these sources are used for water supplies, however, 70% of water supplies are based on groundwater and 30% on surface waters. Pakistan's population has current water supply coverage of 79%.This inadequate supply of water also poses health risks to the consumers because of its poor quality. Faecally contaminated water is a major contributor to waterborne diseases. It is estimated that in Pakistan around 30% of all diseases and 40% of all deaths are attributed to poor water quality. Moreover, the leading cause of deaths in infants and children up to 10 years age as well as mortality rate of 136 per 1,000 live births due to diarrhea is reported. Furthermore, every fifth citizen suffers from illness and disease caused by polluted water.

With rapid urbanization, the chemical aspects of water quality have also become a cause of increasing concern as toxic chemicals in industrial effluents pose a high risk to human health. Unfortunately, little attention is being paid to drinking-water quality issues and quantity remains the priority focus of water supply agencies. There is a lack of drinking-water quality monitoring and surveillance programmes in the country. Weak institutional arrangements, lack of well-equipped laboratories and the absence of a legal framework for drinking-water quality issues have aggravated the situation. Above all public awareness of the issue of water quality is dismally low. The water shortage and increasing competition for multiple uses of water adversely affected the water quality.

Keeping in view the above mentioned facts an attempt has been made to evaluate the water quality in some of the already installed water filtration plant with set goals i.e. water quality evaluation before and after treatment of water, water filtration plants Performance assessment and Suggest and recommend guidelines for their improvement.

A research study was started to evaluate the energy efficiency of a sample of drinking water treatment plants (DWTPs) using the data envelopment analysis (DEA) tolerance method. The results showed that, even in the best-case situation, most of the DWTPs evaluated were inefficient and might be able to reduce the energy used to treat raw water. As policy perspective the results revealed that omitting data variability in benchmarking would involve critical repercussions when efficiency scores were used by regulators to set water tariffs. Omitting the degree of data uncertainty was likely to result in biased conclusions; in the scenarios evaluated, the inclusion of this information altered the rankings of some energy-efficient DWTPs [Sala-Garrido, R., & Molinos-Senante, M., 2020].

A quantitative microbial risk assessment (QMRA) study was conducted on *Cryptosporidium* using actual pathogen density to know the performance conventional water treatment plant (WTP). To control the excess risk, three QMRA-based disinfection scenarios were examined; (1) employing chlorine dioxide instead of chlorine (2) ozonation with a concentration of 0.75mg/L (3) UV irradiation with a dose of 10mJ/cm^2. The results showed that use of ozone or UV as alternative disinfectants could enhance the disinfection efficacy and provide sufficient additional treatment against the excess risk of parasite. QMRA could make it easier applying appropriate improvement to conventional WTPs in order to increase the system performance in terms of health-based measures [Hadi, M *et al.,* 2019].

A study was started with aimed to evaluate the efficacy of real-time bacteriological counters for continuously assessing the performance of a full-scale sand filter to remove bacteria of a drinking water treatment plant. Periodic variations were found with online bacterial counts in the sand filter influent because of the changes in the performance of flocculation and sedimentation processes. Overall, online removal rates of bacteria determined during the full-scale test were 95.2-99.3%. Real-time bacteriological counting technology could be a useful tool for assessing variability and detecting bacterial breakthrough. It could be integrated with other online water quality measurements to evaluate underlying trends and the performance of sand filters for bacterial removal, which could enhanced the safety of drinking water [Fujioka, T *et al.,* 2019].

A hybrid statistic model named HANN was established by combining artificial neural network (ANN) with genetic algorithm (GA) aiming at forecasting the overall performance of drinking water treatment plants (DWTPs) was carried out. Water quality parameters like temperature, chemical oxygen demand (COD) and operational parameters like electricity consumption and chemical consumption were selected as input variables while drinking water production was employed as the output. The scenario analysis showed that the HANN model was capable of predicting water production variation based on the parameter variations. It was found that the HANN model could be a general management tool for decision makers and DWTP managers to make plans in advance of regulatory changes, source water quality variations and market demand [Zhang, Y *et al.,* 2019].

Adequacy analysis of drinking water treatment technologies in regard to the parameter turbidity, considering the quality of natural waters treated by large-scale water treatment plants (WTPs) was initiated. Nonparametric and multivariate statistical tools were used to analyze raw water and treated water turbidity of a large on-line monitoring databank for the period of two years of six large-scale treatment plants utilizing different technologies. The results depicted that selection of the technology to be applied must be well studied to always seek the best solution, and that other factors than only the raw water characteristics should be evaluated. It was also found that utilization of the same treatment technology did not always resulted in the same effluent quality, since there were many factors related to operation, maintenance, raw water variability, climatic interferences, and others [Melo, L. D. V., *et al.,* 2019].

A study was started with the objective to evaluate the drinking water treatment plant (DWTP) by life cycle assessment (LCA) and to identify and characterize its environmental impacts. DWTP involved the scheme; pre-oxidation (chlorine dioxide), coagulation/ flocculation, sedimentation, pH correction (calcium hydroxide), rapid sand filtration, granular activated carbon filtration and disinfection (chlorine gas). Life cycle impact assessment showed that the lower the pollutant concentration, the higher the specific environmental impacts would be, which prompts for further detailed analysis of water treatment plant environmental performance in at least two directions i.e. removal of emerging contaminants (present in very low concentrations) and a more detailed analysis on the individual performance of each treatment stage [Barjoveanu, *et al.,* 2019].

A study was conducted to analyze the presence of antibiotics in potable water from two treatment plants. The collected samples were separated using a solid-phase extraction method with hydrophilic-lipophilic balance cartridge before being analyzed. The detected antibiotics in the raw and finished drinking water were analyzed and assessed using high-performance liquid chromatography with fluorometric detector and UV detector. The results proved that different antibiotics including fluoroquinolones and *B*-lactams were detected in the raw and finished water. It was suggested that due to presence of antibiotic drugs in raw and finished water, the planners should include it in the respective country standard for drinking water quality assessment [Mahmood, A. R *et al.,* 2019].

A study was conducted to assess the efficiency of two natural-based coagulants, namely calcium lactate and tannic acid, and compare it with conventional coagulants polyaluminium chloride and ferric chloride in a water treatment plant. The comparison between the performances of the coagulants showed no significant difference in turbidity removal. However sludge volume produced as well as the impact on PH alteration after coagulation-flocculation were lower when using natural coagulants than with conventional coagulants. The results showed that the natural coagulants could be preferable to the conventional coagulants if the concerns regarding disinfection by-product formation due to their residual organics were resolved [Kaji, A *et al.,* 2019].

Performance Evaluation of a Drinking Water Treatment Plant in terms of performance, design, operation, and maintenance was carried out. A Microbial Barrier Analysis (MBA) and Quantitative Microbial Risk Assessment (QMRA) were performed to assess the health risk based on the Water Safety Plan concept. The results revealed that less source protection, lack of skilled expertise in operation, deficiency of guidance from the administration, insufficient design and equipment, and incomplete technologies were the main issues. Recommendations in a two-step implementation plan were presented to provide of an adequate water supply [Braun, M., 2019].

Evaluation of energy performance of drinking water treatment plants was initiated by Using energy intensity and energy efficiency metrics. The metafrontier data was used in envelopment analysis to evaluate and compare the energy performance of four types of treatment technologies. This approach integrates energy intensity with pollutant removal efficiency into a single, synthetic index to deliver an energy-efficiency score. The results showed that facilities using rapid-gravity filtration and coagulation-flocculation processes provided the highest energy efficiencies. But energy intensity and energy efficiency metrics delivered contradictory results that showed the importance of including pollutant removal efficiency data in performance assessments. It was found that this study gave valuable information for policy-makers when planning and developing new drinking water treatment plants and for water utility managers when identifying energy reduction opportunities in plants [Molinos-Senante, M., & Sala-Garrido, R., 2018].

A complete review of research efforts related to the occurrence, fate, health effects and impacts of emerging pollutants on advanced drinking water treatment and the environmental performance evaluation of different technological options, with a focus on pilot and full-scale installations was carried out. A full analysis of environmental assessment instruments like life cycle assessment, carbon, water footprints, other type of assessments was done that would be used for selecting sustainable advanced drinking water treatment processes and able to removed emerging pollutants. this study vitally reviewed the emerging pollutants included classification, legislative framework, up-to-date removal processes and their environmental performances assessment and to offer a detailed analysis of the strategic issues that might constitute future research directions for sustainable water supply [Teodosiu, C *et al.,* 2018].

A study was initiated for Prediction of operation efficiency of water treatment plant with the help a new index-based method for evaluation of the performance of the surface water treatment plants. The index was developed with compensatory Multi-criteria decision-making methods to make the index relative as well as objective. The results showed that labor efficiency, length and density of pipelines were found to be the most and least significant parameter in regulating the performance of water treatment plants. The new method was applied to evaluate the performance of a densely populated urban surface water treatment plant and suggested for further application of the method [Choudhury S *et al.,* 2018].

An Overview of the main disinfection processes for wastewater and drinking water treatment plants was carried out to know the conventional processes, the action mechanism, the possible formation of by-products, the operative conditions, the advantages and disadvantages. The action mechanisms were found for advanced and natural processes.

Advanced technologies were interesting but were still in the research state, while conventional technologies were the most used. It was found that there was a tendency to use chlorine-based disinfectant, although some forms could lead to production of disinfection by-products [Collivignarelli *et al.,* 2018].

A study was conducted to know the Spatial Assessment and the Most Significant Parameters for Drinking Water Quality Using Chemometric Technique in Water Treatment Plants. The results showed that Discriminant Analysis and One- Way Analysis of variance successfully reduced the physico and inorganic pollutants concentration with significant value 98.63% and 96.90%. principle component analysis revealed six most significant drinking water quality parameters for pesticides parameters, nine significant parameters for Inorganic parameters, fourteen parameters on heavy metals and organic parameters and four significant of PPs with the p value less than 0.05 ($p < 0.05$). Therefore, this study proved chemometric method was the alternative way to explain the characteristic of the drinking water quality and could reduce several parameters and sampling points in the future sampling strategy [Zolkipli, H. M *et al.,* 2018].

A study was conducted to know the Performance management of small water treatment plant operations by means of a decision support system. A decision support system (DSS) was developed to optimize the performance of different operations related to a small water treatment system to improve its day-to-day decisions. It includes a data management system, knowledge-based system, performance assessment of different unit processes, fault tree analyses, preventive and corrective actions and event tree analysis (ETA).

ETA was used to identify the potential health outcomes which were further integrated with the quantitative microbial risk assessment. The developed DSS was an automated user friendly program which could be used by treatment plant operators to assess system performance [Stein, D *et al.,* 2017].

A research study was initiated for assessment framework using performance-based water quality indices (P_{WQI}) was developed to facilitate senior management of ground WTPs for effective decision-making. Five most important water quality parameters (WQPs) had been selected to assess the performance of different components of the WTP, including raw water, pre-treatment, ultrafiltration, sand filtration, reverse osmosis, and final product. The results showed that all the units consistently performed "high," and the plant was meeting drinking water quality standards throughout the year. Hypothetical scenario analysis revealed robustness of the developed framework by showing lacking performance in case failure of different units [Haider, H *et al.,* 2017].

An Evaluation of water quality and performance for a water treatment plant was done to assess the efficiency of water treatment plant and to evaluate the treated water quality of distributed to city residents. Under this several physicochemical and bacteriological parameters of both the raw and treated water samples were analyzed according to Standard Methods and Procedures to evaluate the performance and quality of treated water from Water Treatment Plant. The results showed that the source raw water was moderately of poor quality, while the treated water was relatively satisfactory. The treatment process units were also evaluated. On the whole removal efficiency of water turbidity was 97.88%. it was suggested that the water treatment plant units and process operation needed to be improved, rescaled, and redesigned to enhance the plant efficiency and reduce the possibilities of waterborne diseases and contamination that might occur in future in City drinking water [Issa, H. M *et al.,* 2017].

Comparison of in vitro estrogenic activity and estrogen concentrations in source and treated waters from 25 US drinking water treatment plants were investigated under this study. treated water samples were tested for estrogenic activity using T47D-KBluc cells and analyzed by liquid chromatography-Fourier transform mass spectrometry for natural and synthetic estrogens (including estrone, 17β-estradiol, estriol, and ethinyl estradiol). It was concluded that using in vitro techniques in addition to analytical chemical determinations was displayed by the sensitivity of the T47D-KBluc bioassay, coupled with the ability to measure cumulative effects of mixtures, specifically when unknown chemicals might be present [Conley, J. M *et al.,* 2017].

A study of Microbial risk assessment of drinking water to fix health-based performance issues to improve water quality and treatment plant operations was done by a country organization. The investigating organization had examined by adopting the Australian Guidelines for Water Recycling (AGWR) methodology for drinking water risk management, and spent in the development of a convenient and practical quantitative microbial risk assessment (QMRA) tool for rapid assessment and reporting of the microbial safety of its drinking water systems. This action resulted in the identification of several drinking water system performance deficiencies, and recommendations for system improvements and optimization to improve health risk management to customers [Shea, A *et al.,* 2016].

For evaluation of water treatment plants performance, Applicability of statistical tools was applied under this study. The results found during the wet and dry season were set apart. The results depicted the feasibility of these statistical tools while considering the effluent turbidity as the main parameter. Statistical analysis showed that performance level of the plants was not dependent on their sizes or raw water quality. It was found that plants performance was reduced during the wet season as compared to the dry season [Melo, L. V *et al.,* 2016].

Invariably ground waters are supplied for human consumption without any treatment at all or after disinfection only. From the reported results it is evident that the contamination of groundwater sources, if not controlled, may cause substantial damage or irreversible deterioration of the groundwater quality in future. Drinking-water quality is largely influenced by the source water quality, the extent and efficacy of the treatment rendered and the integrity of the distribution system. Poor microbial quality of drinking-water from both ground and surface waters is the most pressing issue. No water supply in urban areas of Pakistan meets WHO drinking-water quality guidelines. The major reasons for this include: (1) leakage of pipelines; (2) layout of freshwater pipes parallel or beneath the sewerage pipes or channels; (3) overloading of sewerage channels and pipelines which remained in most cases blocked and overflow into surface drains and natural water channels; and (4) disposal of untreated wastewater into major rivers. Over-pumping of groundwater due to extended draught has also affected the water quality adversely.

The present study has been planned to evaluate the quality of water after treatment at different filtration plants sites of cantonment board Sialkot. Cantonment board Sialkot is the responsible authority for water supply and sanitation of the area. Treatment plants work according to a set timetable. Chlorination is being carried out at almost every source.

The comparison of test results clarifies the potential sources of contamination in water filtration plants, if any. In this research, water quality both before and after treatment is evaluated. It helps in identifying the problem areas for initiating appropriate corrective solutions.

Material and methods

Introduction to Study Area

The study area is Sialkot, which is located near the River Chenab and close to the Pakistan-India border. It is comparatively a flat area. Its weather is extreme during the months of May, June, and July, when the temperatures rise to 40–45 °C. In August, the monsoon seasons starts, with heavy rainfall throughout the province. December, January, and February are the coldest months, when temperatures can drop to -1 °C.

Sampling Plan

Water samples from source i.e. treatment plant (In and out) were collected and analyzed for physical, chemical and bacteriological quality from research laboratories. For this purpose, six treatment plants were selected. Sampling from each location was done before and after treatment as per WHO guidelines. For the statistical significance of the testing results, samples from each sampling location were collected and tested. In this way, total Twelve (12) samples were collected and tested. Thirty three parameters (physical, chemical and bacteriological) were determined for each sample.

Sampling and Preservation

All the sampling and preservation procedures for water samples were performed according to Standard Methods for the Examination of Water and Wastewater, 1998 and Guidelines for drinking water quality (WHO).

Sampling for bacteriological analysis was done aseptically with care, ensuring that there was no external contamination of the samples. For bacteriological analysis sampling, sterilized plastic Poly Ethylene (PET) bottles of 1.5 litre capacity were used, cleaned and rinsed carefully, given a final rinse with distilled water, and sterilized at 121°C for 15 minutes, as directed in section 9030 & 9040 of standard methods. For physicochemical analysis, samples were collected in Poly Ethylene (PET) bottles of 1.5 litre capacity, properly washed with the sampling water for three times. Sample bottles were marked with date and sample ID using indelible ink.

During sample collection, ample air space was left in the bottle (at least 2.5 cm) to facilitate mixing by shaking, before examination. Sample bottles were kept closed until filled (without rinsing) and caps were replaced immediately. In case of water samples from distribution network, un-rusted taps supplying water from a service pipe, directly connected with the main and not served from a storage tank, were selected. Tap was opened fully, and water was let run to waste for 2 or 3 minutes, and then water flow was reduced to permit the filling of bottle without splashing.

Samples were not taken from those taps, which were leaking between the spindle and gland to avoid outside contamination. All the samples were fetched to the research laboratory within the recommended time period.

Examination of Water Quality Parameters

The water samples were analyzed for physical, chemical and bacteriological parameters by using standard methods (W.H.O Guidelines for Drinking Water).

Physical, Chemical and Bacteriological Examination

Water samples from source i.e. treatment plants (In and out) were collected and analyzed for physical (i.e. colour, taste, odour, Turbidity) chemical(i.e. pH, Conductivity at 25 °C, Total dissolved solids, Total suspended solids, Total Hardness as $CaCo_3$, Calcium, Magnesium, Calcium as Ca^{2+}, Magnesium asmg^{2+}, Total alkalinity as $CaCo_3$, Bicarbonate as CaCo3, Carbonate as CaCo3, Bicarbonate as HCO_3^{1-}, Carbonate as CO_3^{2-}, Chloride as Cl^{1-}, Sulphate as SO_4^{2-} ,Sodium as Na^{1+}, Potassium as K^{1+}, Iron as Fe^{2+}, Nitrite as No_2^{1-}, Nitrate as NO_3^{1-}, Silica as SiO_2 and bacteriological (i.e. coliforms, faecal coliforms, E. coli etc) quality from PCSIR Laboratories Pakistan. Sampling from each location was done before and after treatment as per WHO guidelines. For the statistical significance of the testing results, samples from each sampling location were collected and tested. In this way, total Twelve (12) samples were collected and tested.

Results and discussion

The test results of physical, chemical and bacteriological parameters of total 12 samples taken from six treatment plants are being discussed individually, in comparison with others and in overall basis their performance in the below mentioned sections.

Physical Chemical and Biological Parameters

Treatment Plant No. 1

Test results of treatment plant No. 1 depicted that all the parameters tested were fallen within WHO guideline values, although Conductivity at 25°C and Total Dissolved Solids had a little bit higher value but remained in the limit. The water at source was satisfactory before and after treatment. This treatment plant was performing well.

Treatment Plant No. 2

Test results of treatment plant No. 2 showed that all the parameters tested for Treatment were laid within

WHO guideline values and the water at source was satisfactory before and after treatment. The treatment plant was performing well.

Treatment Plant No. 3

Test results of treatment plant No. 3 was evidenced that all the parameters tested were fallen within WHO guideline values and the water at source was satisfactory before and after treatment. The treatment plant was performing well.

Treatment Plant No. 4

Water samples of this Treatment plant before treatment was found unsafe for drinking, both chemically and biologically as Total alkalinity as $CaCO_3$, Total and Fecal Coliforms were greater than WHO guideline values. The good thing was what the treatment plant was working well and it removes these contaminations present before treatment. The water at source was satisfactory only after treatment.

Treatment Plant No. 5

Test results of treatment plant No. 5 before treatment was found unsafe for drinking, biologically as Total and Fecal Coliforms were greater than WHO guideline values. The water at source was satisfactory only after treatment. The plant was performing well.

Treatment Plant No. 6

Test results of treatment plant No. 6 was evidenced that all the parameters tested for this Treatment Plant were fallen within WHO guideline values and the water at source was satisfactory before and after treatment.

Comparison of Different Water Quality Parameters

Physical and chemical parameters

As for as Colour, Taste and Odour of collected water samples from all six filtration plants were found colourless, tasteless and odourless, which were the most common symptoms for the assessment of water quality. For Total Suspended solids, Carbonate as $CaCO_3$, Carbonate as CO_3^{1-}, it was found that these parameters were not present in all these samples taken from the treatment plants, although total dissolved solids were present.

The pH was within WHO Guidelines for drinking water for all samples taken from water filtration plants (Fig. 1). For Calcium all the samples seemed to be within the limits of PCSIR laboratories, as no WHO guidelines was available for this parameter of Drinking (Fig. 2).

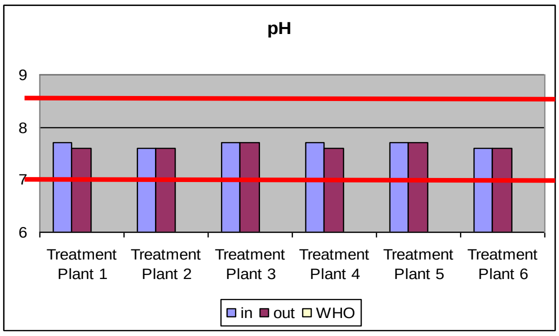

Fig. 1. pH of water samples.

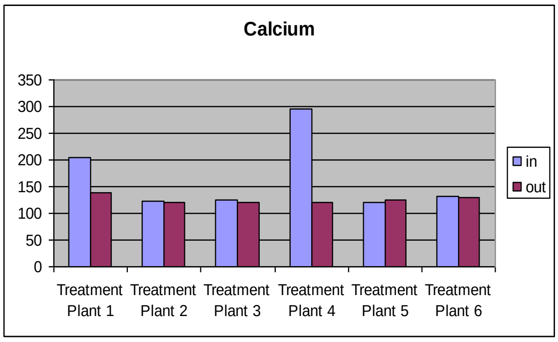

Fig. 2. Calcium of water samples.

As for Total alkalinity as $CaCO_3$, all the water samples were within the permissible limits of WHO guidelines for total alkalinity (500 PPM) expect at inlet of water treatment plant No.4 (Fig. 3). For Sulphate as SO_4^{2-}, all the water samples were within the permissible limits of WHO guidelines for Sulphate as SO_4^{2-}i.e. 400 PPM (Fig. 4).

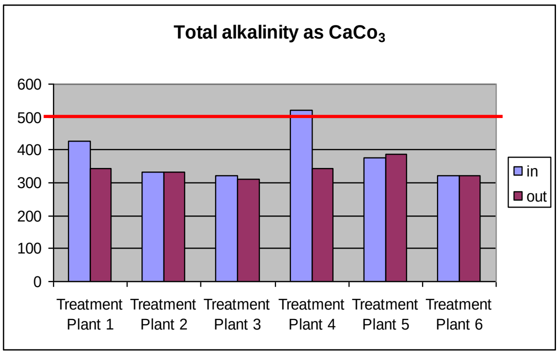

Fig. 3. Total alkalinity as $CaCO_3$ of water sample.

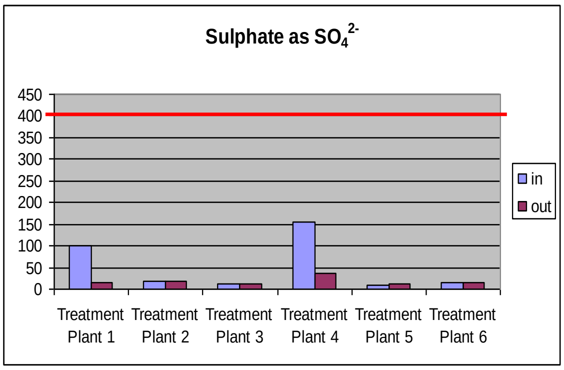

Fig. 4. Sulphate as SO_4^{2-} of water sample.

All the water samples were within the permissible limits of WHO guidelines (0.5) for Nitrate as $NO21^-$ (Fig. 5). For Conductivity at 25ºC, all the samples seemed to be within the limits provided by PCSIR laboratories Pakistan, as no WHO guidelines available for this parameter of Drinking Water (Fig. 6).

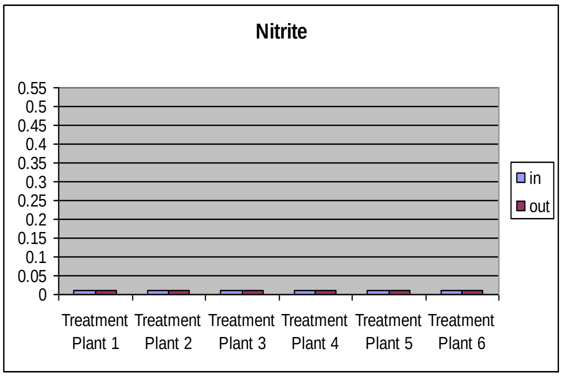

Fig. 5. Nitrate as NO_2^{1-} of water samples.

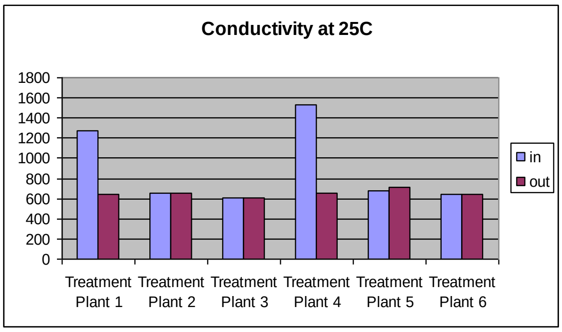

Fig. 6. Conductivity at 25ºC of water samples.

All the water samples were found within the permissible limits for Total Dissolved Solids as per WHO guidelines for Nitrate (1500) as total dissolved solids (Fig. 7). For Total Hardness as $CaCO_3$, all the water samples were within the permissible limits given by WHO guidelines (500) shown in Fig. 8.

For Magnesium asmg^{2+}, all the water samples were within the permissible limits 200 given by WHO guidelines (Fig. 9). Results showed that Calcium as Ca^{2+}, for all the water samples were within the permissible limits as per WHO guidelines i.e. 200 (Fig. 10).

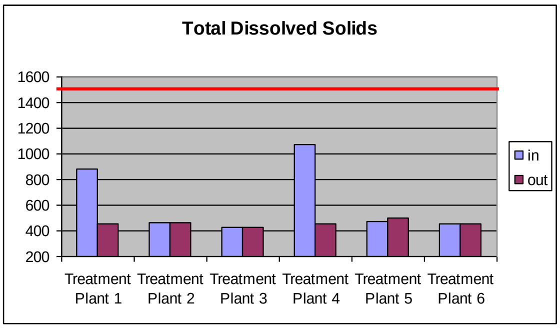

Fig. 7. TDS of water samples.

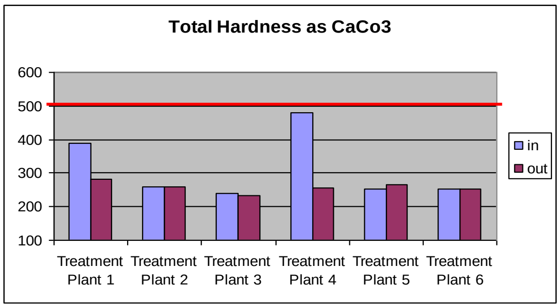

Fig. 8. Total Hardness as $CaCO_3$ of water samples.

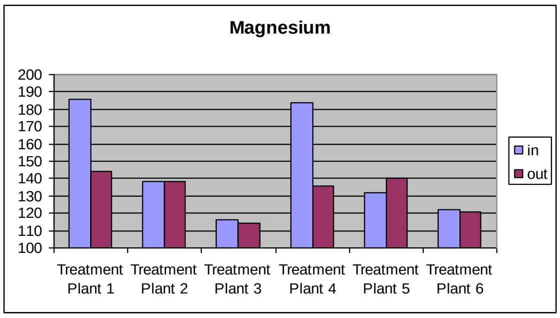

Fig. 9. Magnesium asmg2+ of water samples.

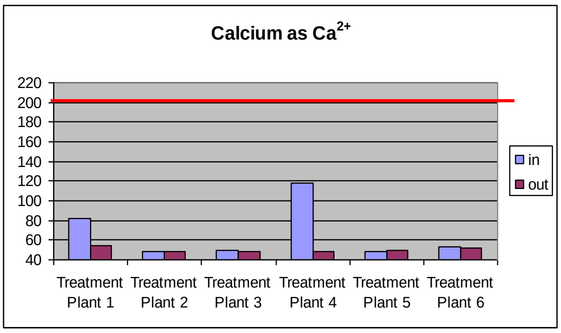

Fig. 10. Calcium as Ca^{2+} of water samples.

The results showed that Bicarbonate as $CaCO_3$ was seemed within the limit provided by PCSIR laboratories Pakistan for all samples. As there were no WHO guidelines available for this parameter of Drinking Water. All the samples were seemed to be within the limits for Bicarbonate as HCO_3^{1-} according to the results provided by PCSIR laboratories Pakistan. For this parameter WHO guidelines for Drinking Water was not available.

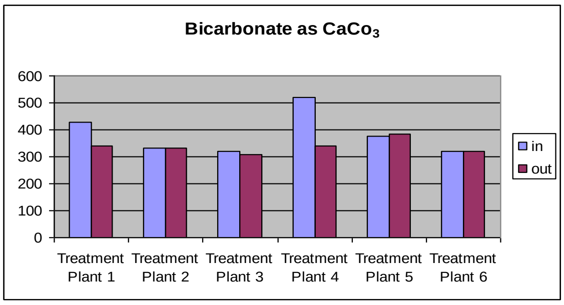

Fig. 11. Bicarbonate as $CaCO_3$ of water samples.

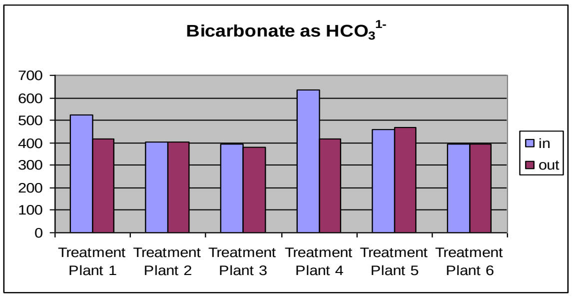

Fig. 12. Bicarbonate as HCO_3^{1-} of water samples.

The results showed that all water samples were within the permissible limits for Chloride as Cl^{1-}as per WHO guidelines i.e. 200 (Fig. 13). For Sodium as Na^{1+}, all the samples were seemed in within the limits as per results provided by PCSIR laboratories Pakistan (Fig. 14). For this parameter of Drinking water WHO guidelines was not available.

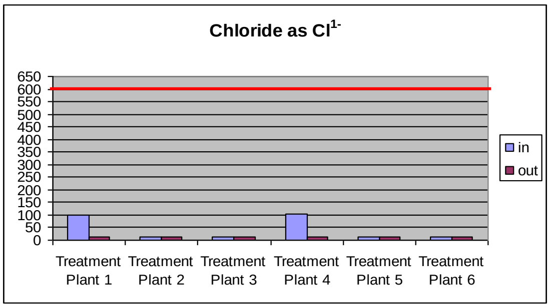

Fig. 13. Chloride as Cl^{1-} of water samples.

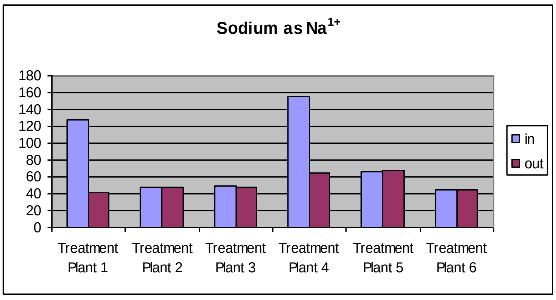

Fig. 14. Sodium as Na^{1+} of water samples.

The results depicted that Potassium as K^{1+}, were found within the limit, according to the results provided by PCSIR laboratories Pakistan (Fig. 15). As no WHO guidelines was available for this parameter of Drinking Water. All the water samples were within the permissible limits as per WHO guidelines for Iron as Fe^{2+} (Fig. 16).

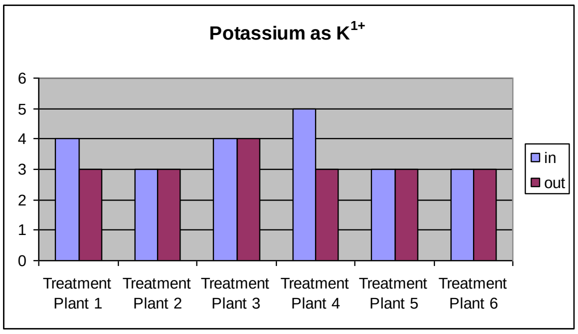

Fig. 15. Potassium as K^{1+} of water samples.

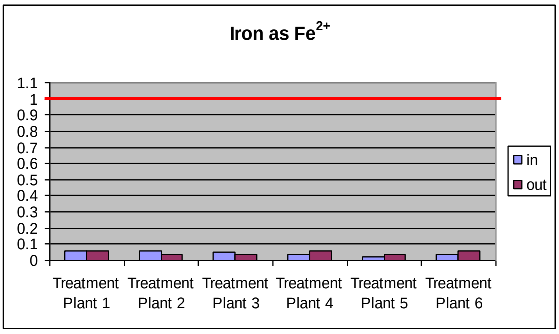

Fig. 16. Iron as Fe^{2+} of water samples.

Although there were no WHO guidelines available for Nitrate as NO_3^{1-} parameter of Drinking Water, but according to the results provided by PCSIR laboratories Pakistan, all the samples were seemed within the limits (Fig. 17). For Silica as SiO_2, results showed that all the water samples were within the permissible limits provided by WHO guidelines for Silica as SiO_2 i.e. 14 (Fig. 18).

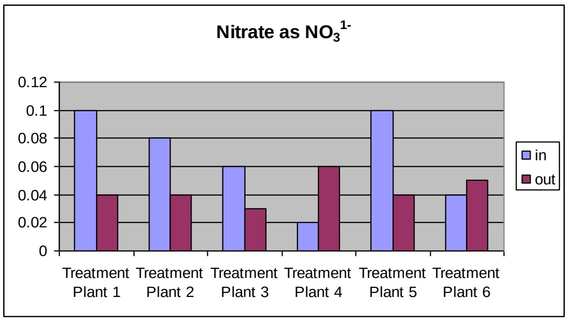

Fig. 17. Nitrate as NO_3^{1-} of water samples.

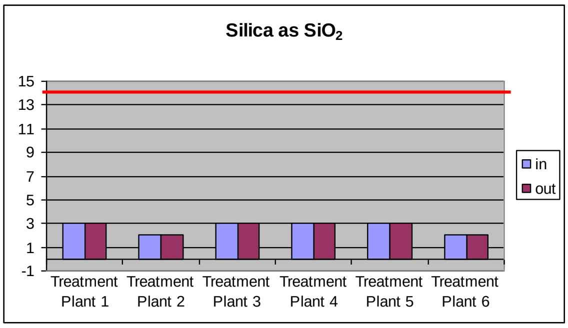

Fig. 18. Silica as SiO_2 of water samples.

Biological Parameters

All of the water samples taken from different treatment plants were found safe for drinking water, expect water of treatment plants No. 4 & 5 before treatment. Total and Fecal coloform was present in it. It was interesting to note that treatment plants were working well and they removed the bacteriological load as well.

Discussion

Thirty three parameters (physical, chemical and bacteriological) were determined for each sample. All the sampling and preservation procedures for water samples were performed according to Standard Methods for the Examination of Water and Wastewater, 1998 and Guidelines for drinking water quality (WHO). The water samples were analyzed for physical, chemical and bacteriological parameters by using standard methods.

The physicochemical and bacteriological parameters for all treatment plants were within the desirable limit for drinking water quality recommended by WHO except Treatment plant No. 4 and No. 5 before Treatment. Water filtration plants were installed because the water available from the network supply lines were not good for drinking, but it was evident from the results that mostly the water at the source was almost fit for drinking water purpose without filtration plants except for treatment plant No. 4 & 5 for which some biological parameters were not according to standards. This shows that before the installation of filtration plants a water sample test of physical, chemical and bacteriological parameters must be conducted and compared with the WHO standards to avoid unnecessary installation of water filtration plants. In this case if test was conducted beforehand out of six only two filtration plants were necessary and the money spent on unnecessary filtration plants could have been used for betterment of water supply system. Chlorination was one of the most effective and popular method practiced throughout the world for disinfection of water supply lines. It could be used instead of these treatment plants as it is much more cost effective.

Conclusion

The physiochemical and bacteriological parameters for all treatment plants were within the desirable limit for drinking water quality recommended by WHO except for the treatment plant No 4 & 5, before treatment, which contained Total and Fecal coloform in it.

Recommendations

- Periodic evaluation of some important parameters like bacterial load especially indicating faecal pollution (coliforms, faecal coliforms, E. coli etc.), free residual chlorine, turbidity, pH and TDS should be carried out both before and after treatment to ensure safe water supplies for drinking.
- To prevent biological contamination water and sewerage pipelines should always be laid in separate trenches preferably at some distance from water source. Also the sewerage water should not be injected into the groundwater through seepage pits.
- There is a need for Public awareness campaigns, which should be launched to educate people about the importance of safe drinking water. Potable water safety and its hazards should be publicized. Media and nongovernmental organizations can play a pivotal role in this aspect.

Novelty Statement

The present study has been planned to evaluate the quality of water after treatment at different filtration plants installed at various sites of Pakistan. Treatment plants work according to a set timetable. Chlorination was being carried out at almost every source. The comparison of test results clarifies the potential sources of contamination in water filtration plants, if any. In this research, water quality both before and after treatment is evaluated. It helps in identifying the problem areas for initiating appropriate corrective solutions.

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