QUALITY OF FILTERED DRINKING WATER IN ISLAMABAD
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Published by: IUCN Pakistan.

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Citation:

IUCN. 2015 Quality of Filtered Drinking Water in Islamabad. IUCN Pakistan, pp 45.

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Quality of Filtered Drinking Water in Islamabad
Aasia Wahab¹, Huma Farooq²

1. THE CONTEXT

1.1 Background

Water is essential for the survival of all living things. Without water, humans would die in a few days, crops would not grow and food would run short. Unfortunately this resource of water is declining and is under great threat due to many global influences caused by anthropogenic activities i.e. rapid increase in population, urbanization, industrialization and pollution. Pakistan will shortly become a water-stressed country. Water will be a luxury in near future, especially clean water. It is therefore crucial to consider the state of water quality. The water quality situation in Pakistan is an environmental catastrophe. The water quality situation is in disarray. Untreated waste water, industrial effluent and agricultural run-off is poisoning the water for all people and natural habitats. Pakistan is one of those countries where about 82% of the people do not have an access to clean drinking water, 30-40% patients are hospitalized due to water borne diseases, and about 80% of the infant deaths occurs because of the polluted water that causes diarrhea, cholera and other gastro-intestinal problems.³

According to the study recently conducted by Pakistan Council of Research in Water Resources (PCRWR), the results obtained for the quality of water in most of the water supply systems is below the quality standards set by the World Health Organization (WHO). Some of the causes of degradation of water quality are damaged pipes and connections, leakages, poor administration, lack of funds and resources and most importantly microbial and chemical contamination. Heavy metals discharges from industries and municipalities contribute to arsenic, nitrate and fluoride contamination while agricultural run off leads to considerable amount of coliforms and pesticides in the water resources.⁴

Islamabad, the capital of Pakistan, is the land of green lush grounds and high mountains of Margalla with the best social, educational and recreational facilities available to the citizens. The area is supplied with water from the two main water sources: Khanpur Dam and Simly Dam. Other sources include tube wells, raw water of open reservoirs and channels, pipelines and service reservoirs. Despite that, this city is facing many water related issues in terms of both quality and quantity. The scarcity of water is evident from drought and famine hit areas while quality of water is well portrayed by water borne diseases.

Water quality assessment conducted by PCRWR revealed that about 75% of water in Islamabad is not fit for human consumption because of bacterial contamination. For this purpose the water supply authorities like Capital Development Authority (CDA) ensured the supply of safe water up to consumer end by installing water filtration plants, in addition to adding appropriate doses of chlorine and fulfilling effective treatment conditions. These steps have, to some extent, reduced the risk of water borne diseases and many other detrimental effects on consumers. Although these filtration plants can be useful in providing clean drinking water to the locals yet there is a chance that these plants might turn out to be the breeding grounds of water borne diseases if they are not properly maintained by the authorities and public.

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1.2 Problem Statement

The basic vision of the study is to monitor and analyze the drinking water quality of filtration plants in Islamabad installed by CDA and to aware the people regarding the current situation of water quality available in these filtration plants.

But the commonly faced problem by the citizens of Islamabad is the access to safe drinking water mainly due to deterioration of water quality due to the outdated infrastructure of water supply schemes, breakage in distribution systems, inadequate technical capacity of water supply agencies and lack of awareness on quality issues ultimately leading to serious water borne diseases like cholera and diarrhea.

The goals of the study are to conduct a field survey to know the opinion of local people about the water quality and environmental conditions of the filter plant and to carry out the chemical and microbiological analysis of the drinking water quality to check whether it is according to the drinking water standards set by Pakistan Standard and Quality Control Authority (PSQCA-2008), World Health Organization (WHO), Pak EPA (Pakistan Environmental Protection Agency) and EEC (European Economic Commission).

1.3 Target Area

- **I-10/4, I-10 Markaz, I-9/1 and I-8/3 filtration plants**
  I-10, I-9 and I-8/3 are well populated sectors of Islamabad, located on the southwestern edge of the city. These sectors contain CDA water filtration plants in each of their sub sectors but a few filter units are selected for the study.
  I-10/4 filter unit is located on street 23 in front of Islamabad Model College for Girls I-10/4 while I-10 Markaz filter unit is located in the Markaz of the sector on the Sohni road. Another filter unit is located in I-9/1 sector on Gali number 5 near CDA public park. Filter unit in I-8/3 is located on Street 65 at the bank of local park near Mir Chakar Khan Road.

- **F-10 Markaz, G-10/2, G-11/2 and G-11/3 filtration plants**
  F-10 Markaz unit is located in the markaz of the sector on the Service road. All the three filtration plants of G-10/2, G-11/3 and G-11/2 are located adjacent on the Ibn-e-Sina road.

- **G-7/3 and F-6/1 filtration plants**
  F-6/1 filter unit is located in the sector F-6/1 Blue Area on the Jinnah Avenue while the filter unit of sector G-7/3 is located infront of Jamia Noor Masjid.

1.4 Purpose of the Study

The purpose of the study is to carry out the detailed analysis of water samples collected from various filtration plants installed by Capital Development Authority (CDA) in Islamabad and the evaluation and assessment/comparison of water quality parameters of collected samples with the drinking water standards set by Pakistan Standard and Quality Control Authority (PSQCA-2008) and World Health Organization (WHO).

1.5 Scope of the Study

The major objectives of the study are to evaluate the quality of drinking water being supplied to general public by CDA water filtration plants in Islamabad, to compare and analyze the pre and post treatment water quality from filtration plants, to monitor the hygienic conditions at the plant site, and to create awareness of public health regarding contaminated drinking water. For this purpose, our study area is limited to only those urban sectors of Islamabad where water filtration units are installed by CDA. The selection of the filter plants is very specific as only those plants are selected which are operational and with better physical conditions. Most of the plants were un-operational due to mismanagement while some were closed down or destroyed due to constructional purposes. Water sampling at each location is performed according to the water sampling techniques given by PCRWR lab and then the samples are submitted to PCRWR lab for further analysis. The sampling results will further be evaluated and compared with the drinking water standards set by WHO and PSQCA.
Recommendations and suggestions will be given if there is any contamination and necessary steps will be introduced to overcome the contaminants to ensure the provision of clean drinking water to all citizens.

1.6 Detailed TORs

- Preparation of Islamabad map and locate the filtration units
- Select sample size and explain the methodology
- The sample size will be maximum of 10 filtration Units (two sample each unit) totaling 20 samples maximum
- Visit the PCRWR Laboratory and get the list of test to be performed and the cost
- Collect sample bottles from the PCRWR Lab for 20 samples
- Collect two samples from each of the selected filtration unit. One of the water entering the filtration unit (before filtration) and one after filtration. The purpose is to check the quality of filtration – before and after
- Deposit the sample to the selected lab
- Get analysis results
- Collect secondary information from net regarding work already done on filtration of drinking water
- Take Pictures of filtration units including the environmental conditions around the filtration unit
- Anything which you think is important or unique
- Stay at the filtration unit for 3-4 hours and count number of consumers who collect water and take their interview regarding their satisfaction about quality and how often they collect water and what they feel about improvements required. Make a short questionnaire and get my approval
- Describe the study methodology including sampling & analysis procedures
- Join the Pakistan Water Gateway (www.waterinfo.net.pk) and write individual blogs to document your weekly activities. Blogs must include pictures and a brief description of what and how you carried out the tasks. (minimum 500 words)
- Report writing and submission – the outline will include – Background information, Problem statement, purpose of the study, methodology, results, discussion and conclusions
## 1.7 Work Plan and Schedule of Work

<table>
<thead>
<tr>
<th>Activity</th>
<th>June 2014</th>
<th>July 2014</th>
<th>August 2014</th>
<th>Sep 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Documention of proposal</td>
<td>4th week</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Documention of questionnaire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Submission of Proposal and Questionnaire</td>
<td>4th week</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Preparation of map</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Conduction of surveys</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Collection of water samples</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Samples submission to PCRWR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Collection of secondary data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Collection of samples result from PCRWR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Report writing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Report submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. METHODOLOGY

2.1 Review of Previous Studies

The secondary data being selected for review in this report is comprised of research papers on different issues related to contamination and maintenance of water filtration plants, official statistics, monitoring reports and a case study in which investigations have been done for different filtration plants installed in Islamabad and the quality of drinking water provided by them. These studies are taken from authenticated sources and are helpful in designing subsequent primary research by providing appropriate baseline data. These researches provide both qualitative and quantitative data which are analyzed and evaluated through complete analytical and experimental procedures and are represented in the form of tables and graphs to make the information more illustrative.

2.2 Spatial Distribution of Filtration plants in Study Area

The study is conducted in Islamabad. Total 10 filtration plants are chosen, located in different sectors which are easily accessible and approachable for the survey. These study sites are carefully examined through Google maps and each of the sites is shown and highlighted in the maps below:

Figure 1. The map is showing the filtration plants of I-8/3, I-10/4, I-10 markaz and I-9/1 sectors of Islamabad.
Figure 2. The map is showing the filtration plants in F-10 markaz, G-10/2, G-11/2 and G-11/3 areas of Islamabad.

Figure 3. The map shows the G-7/3 and F-6/1 filter plant in Islamabad.
2.3 Selection of Filtration Sites

In order to collect water samples and to evaluate the pre and post treatment water quality from the filtration plants, the selection of filter sites is a very crucial factor. The filtration plants were selected keeping in mind their suitability in terms of their location, design and landscape. Since many filtration plants were not operational and destroyed because of constructional activities and other purposes, only those units are selected which were of better hygienic conditions and operational capability. These filtration plants are located in the urban sectors of Islamabad and were easily accessible for the public. The sectors where the filter units are located include:

- I-10/4
- I-10 Markaz
- I-8/3
- I-9/1
- G-7/3
- G-10/2
- G-11/2
- G-11/3
- F-6/1
- F-10 Markaz

2.4 Sample Size and Water Sampling

The sample size of filtration plants selected is 10 filtration Units, that is one unit located in each of the sectors mentioned above. For the purpose of water sample collection, sterilized bottles and 1.5 liters mineral water bottles were used. These bottles were also assigned different labels according to the sectors and filter units.

Four samples were collected from each of the selected filtration unit; two samples of the water entering the filtration unit i.e. before filtration and two after filtration. All the collected samples were then submitted to the National Water Quality Lab of PCRWR for further experimental analysis. 

Table 1. The table is showing the number of water samples collected from designated filtration plants from two specific areas i.e. pre-treatment and post-treatment.

<table>
<thead>
<tr>
<th>SELECTED LOCATION</th>
<th>SAMPLES PRE-TREATMENT</th>
<th>SAMPLES POST-TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-10 MARKAZ</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I-8/3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>I-10/4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>F-6/1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>F-10 MARKAZ</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>G-7/3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>G-11/2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>G-11/3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>G-10/2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I-9/1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Sample Size</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

For a field survey to know the local people opinions about the water quality and environmental conditions of the filter plants, the sample size was selected according to the people visiting the filter units. The sample size for 10 selected filter units are as follows:
Table 2. This table shows the field survey samples in the selected locations of filtration plants in Islamabad.

<table>
<thead>
<tr>
<th>SELECTED LOCATION</th>
<th>SAMPLE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-10 MARKAZ</td>
<td>8</td>
</tr>
<tr>
<td>I-8/3</td>
<td>8</td>
</tr>
<tr>
<td>I-10/4</td>
<td>8</td>
</tr>
<tr>
<td>F-6/1</td>
<td>7</td>
</tr>
<tr>
<td>F-10 MARKAZ</td>
<td>8</td>
</tr>
<tr>
<td>G-7/3</td>
<td>6</td>
</tr>
<tr>
<td>G-11/2</td>
<td>9</td>
</tr>
<tr>
<td>G-11/3</td>
<td>8</td>
</tr>
<tr>
<td>G-10/2</td>
<td>9</td>
</tr>
<tr>
<td>I-9/1</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total Sample Size</strong></td>
<td><strong>79</strong></td>
</tr>
</tbody>
</table>

2.5 Analysis of Water Samples

The accuracy of analysis is achieved through spot-on sampling, storage and transportation. Next to the collection of water samples, they are properly preserved and transferred to the National Water Quality Lab of PCRWR. The collected samples go through certain analytical and experimental procedures comprising the tests to be performed for water quality assessment. The tests are referred to different methods used for microbiological and chemical analysis of water samples. The water quality parameters like total coliforms, E.coli, pH, hardness etc are analyzed and compared with the drinking water quality standards set by PSQCA and WHO.

2.6 Users’ Response - Questionnaire and Pre-test

The primary research was conducted with the help of semi structured questionnaires. The questionnaire was concise and contained a structured set of questions designed to elicit the perceptions of local individuals. The questions are basically based on the issues related to the water supply by the filtration plants such as major water supply source, filtered water quality, treatment of filtered water, cost of filtered water, hygienic conditions of the filtration plant, water shortage during summers, commonly faced water borne diseases, actions by the concerned authorities and the suggestions for the improvement in water quality and management of the plant.

The questionnaires are pre-tested on the small number of residents of the study areas. The respondents basically include the people who lived nearby the plants and were the regular consumers of the filtered water. Pilot testing was done to check whether the users’ responses are appropriate and valid or not. These responses were then coded and analyzed in spreadsheets, useless data were discarded and meaningful information was obtained for further analysis.

2.7 Data Transfer and Tabulation

As the transcript of data collection was in Ms. Word format so the data were transferred to the Excel Spreadsheets for analysis. The responses were transferred to the individual cells and given specific serial numbers. Each column represented an individual question and each row was designated to an individual respondent. The data were tabulated in the form of binary digits 1 and 0 to make the analysis at ease and coherent. Each question was further divided into choices and the one selected was given entry of ‘1’ while those not applicable were denoted by ‘0’ digit. Some questions were also given the choices of yes or no to indicate the responses of individuals.
Table 3. The table shows the representation of user responses by binary digits.

<table>
<thead>
<tr>
<th>Response</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive, Applicable</td>
<td>1</td>
</tr>
<tr>
<td>Negative, Not Applicable</td>
<td>0</td>
</tr>
</tbody>
</table>

2.8 Data Analysis – Frequency Distribution, Descriptive Statistics, etc.

Next to the data transfer and tabulation, the data were analyzed. The analysis was executed with the help of computing frequencies, percentages, averages and then drawing histograms and pie charts to make the results more demonstrative.

2.9 Case studies

During the field survey of filtration plants, many different experiences were faced. All the surveyed plants were presenting a different story through their apparent physical conditions. About 20 filtration units were visited in which approximately 10 units were totally un-operational while the rest units were also in a contemptible condition but somehow fulfilling the water needs of the public. One of the plants in a most miserable condition was of sector G-11/2. The negligence behavior of the public and concerned authorities was at peak at that filtration plant. There were intense growth of algae and fungi on the entrance stairs of the plant, walls and taps. A constant leakage of water from the unrepairable taps presented a scene of muddy pool. The people there were also felt hesitation in answering the questions.

Some plants were equipped with enough taps which were vanished at the second visit to those plants as in the case of G-11/2 and I-10/4 filtration plants. The residents faced many problems regarding inadequacy of drinking water and burglary of taps by thieves and junkies. A peculiar thing to be observed during survey was that the residents have fixed a wooden stick in place of a tap to prevent leakage of water. They have complained to CDA many times but the only thing they heard was the ringing bell of the phone with no response.

A more wiered observation at F-6/1 filtration plant was the hanging of clothes and blankets on the filters by the manager of the control room of the filtration plant. It seemed that the control rooms are used as living rooms by the managers leading to adverse effects on the filters and in turn on the filtered water quality. According to TORs of the study, pre treatment water from filtration plants was also required. Different types of uncooperative behaviors were there to be seen during collection time. Some managers refused to take pre treatment water and started to investigate aggressively while at some filter units, the managers were absent and the control rooms were locked.

During survey, the visit to F-10 sector plants i.e. F-10 Markaz and F-10/1 filter units was tackled with many complains from the locals regarding mismanagement and usage of filters for long duration without timely change. Many white suspended particles have also been seen at the spot during survey which settled down after few minutes. According to some residents’ perspective, these particles are due to addition of some medicies while others referred to improper functionality of the filter system.
2.10 Reporting

The reporting has been done after a thorough field survey of each filtration plant located in Islamabad. The reporting is done in a brief and concise manner after analyzing the results of the survey.
3. FINDINGS OF PREVIOUS STUDIES

3.1 Drinking Water Quality Of Filtration Plants Installed At Islamabad And Rawalpindi

In a case study “Investigation of Drinking Water Quality of Water Filtration Plants Installed at Islamabad and Rawalpindi” conducted in 2005, Pakistan Environmental Protection Agency (Pakistan EPA) has taken initiative measures to check the water quality of water filtration plants installed in Islamabad and Rawalpindi. This study is based on collection of water samples from the plants and the evaluation of water quality by the analysis for almost 16 parameters including bacteriological test.

In 2005, 5 filtration plants in Islamabad and about 26 filtration plants in Rawalpindi were operational. These plants were located using Geographical Positioning System (GPS) and were selected for sampling. The samples were collected and then submitted to laboratory for further analysis.

According to analytical results, values for different water parameters were obtained for both Islamabad and Rawalpindi and then compared with each other by putting the values in graphs to obtain the required results. The parameters mainly discussed in this study are pH, conductivity, Total Dissolved Solids, Dissolved Oxygen, chloride, total hardness, Nitrates, COD and iron.

Some parameters have maximum values in the filtration plants of Rawalpindi like conductivity and TDS while some are present in maximum values in the plants of Islamabad as in the case of pH. Lowest pH of 3.93 was found in one of the filtration plant of Rawalpindi mainly caused by the lack of carbonate minerals from limestone and dolomite in the aquifer. For other parameters, different concentrations were analyzed for both of the cities. Some were estimated to be higher than permissible limits while mostly were below the limits set by Pakistan Standard Institution (PSI).

Many disappointing results were obtained from bacteriological test of the water samples. The ratio of bacterial contamination was very high as 3 out of 5 filter units in Islamabad and 14 out of 26 units in Rawalpindi were contaminated with coliform bacteria mainly because of the defected UV disinfection system installed at those plants. Based on these results, the process of water sampling was again conducted after three months but at this time according to the sampling protocol to test the water samples quantitatively for coliform bacteria by CLEAN. Unfortunately, the bacteriological contamination of these plants was still not improved.

In the end of the study, some recommendations are given to minimize or overcome the microbiological contamination of the filtered water. Timely replacement of filters, use of activated carbon, injection of UV dose of 40 mg/cm² to the filtered water, and highly equipped laboratory facilities with trained and properly qualified persons are recommended for the monitoring of drinking water quality on regular basis. ⁵

3.2 Microbiological Contamination in Water Filtration Plants

Another study “Microbiological Contamination in Water Filtration Plants in Islamabad” conducted by Aliya Hisam et al in 2012, basically aims to determine the frequency of microbiological contamination of water in different water filtration plants in Islamabad. In this research, the microbiological quality of filtered water was determined in terms of total coliforms and Escherichia coli which WHO permit should be less than 2.0 MPN/100 ml.

According to the study, the major sources of drinking water in Islamabad are Simply Dam, Khanpur Dam and tube-wells. The water from these sources is provided to the public after treatment. Being the capital city of Pakistan, Islamabad is expected to have better living standards than the rest of the country. But unfortunately many contamination cases of drinking water are being observed. So, this

study is conducted in order to provide opportunity to the concerned authorities to take appropriate measures to determine and minimize bacterial contamination of water in Islamabad.

This descriptive cross-sectional study is done on properly operational filtration plants which are utilized by the population for domestic use. There are about 37 total filtration plants in Islamabad in which one was not functional and four were inaccessible due to security reasons. The remaining 32 filter units were allocated and selected for water sampling. Water sampling was done according to standard water sampling protocol in sterilized bottles collected from PCRWR and then those samples were transported to PCRWR for the analysis of microbiological contamination by trained persons.

According to the results from PCRWR, different level of microbiological contamination was seen in samples of different sectors of Islamabad. Total coliforms were present in about 13 samples of the filtration plants while 19 samples were free from contamination. E.coli was present in only 8 filtration plants while 24 were free from it. In the case of faecal coliforms, 8 filter units were found to be contaminated with it while 24 were free from it. Thus, microbiologically not contaminated water samples were obtained from only 13 filtration plants where the level of contamination was less than 2.0 MPN per 100 ml.

In the end, they have concluded as less than half of the samples from the filtration plants were found to be microbiologically contaminated while mostly samples were free from contamination. This study has made the authorities to be concerned and responsible for their public, their health and security. They should take all possible measures to provide best available facilities to their people.

3.3 Water Quality of Filtration Plants Installed By CDA

Another study was conducted by PCRWR to monitor the “water quality of filtration plants installed in Islamabad by CDA”, in July 2013.

Out of total 33 filtration units, 28 were monitored because others were damaged and were unoperational and a sampling team was prepared based on well experienced technical professionals. Water samples from each filtration plant were collected according to the American Public Health Association Protocols, were preserved and transported to the National Water Quality Laboratory.

For the analysis of water samples, different water quality parameters, their permissible limits set by WHO and PSQCA and the analytical methods used are also mentioned in this report. After the results being revealed, they were compared with the permissible limits of WHO and PSQCA and drew the following conclusions:

They have found that the filtration plant of G-10/2 is supplying the drinking water with excessive turbidity of 27 NTU while the drinking water being supplied by the filtration plant of F-10/1 has shown the slightly excessive levels of Nitrate i.e. 13 ppm. Thus, only 2 filtration plants showed the problems of Physico-Chemical Contamination.

They have also observed that out of 28 monitored plants, only 6 were providing safe drinking water while 22 filtration plants have shown prevalence of bacteriological contamination in the water being supplied and thus found as highly unsafe. Such bacteriological contamination can result in various diseases like gastro-enteritis, cholera, diarrhea, dysentery, hepatitis A & E, and typhoid.

In the end, different recommendation are given in order to improve the quality of drinking water being supplied by CDA filtration plants like enhancement of capacity building of CDA plant operators, maintenance of hygienic conditions at the plant site and its surroundings, timely replacements of ultraviolet lamps/filtration cartridges, and disinfection practices using chlorination.

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3.4 Performance Evaluation of the Water Treatment Plants

Performance evaluation of the water treatment plants of Islamabad – Pakistan is a study conducted by Ali Arshad et al in 2012 to evaluate the treatability performance of SG-WTP (Sangjani Water Treatment Plant) and SM-WTP (Simly Water Treatment Plant) for a time period of 12 months. SG-WTP treats the water of Khanpur Dam while SM-WTP gives the water coming from Simly Dam and both of these treatment plants are composed of coagulation, flocculation, sedimentation, and rapid gravity filtration and chlorination systems. Furthermore, this study paid utmost attention to the two water quality parameters; the turbidity and coliforms. These parameters are the most reliable and standard factors for the performance evaluation of the treatment plants.

Water samples including both samples from upstream side of the plants and at the exit, were collected from the treatment plants at regular interval of fifteen days in sterile glass bottles containing few drops of 3% sodium thiosulfate to neutralize the residual chlorine.

The results indicate that the water samples collected on the upstream side of filters were highly contaminated with total coliform and fecal coliforms mainly due to anthropogenic activities and cattle grazing along the bank of the canal. Different physico-chemical characteristics of the water samples at the exit of both treatment plants were also analyzed. The results exhibited that the values of various water quality parameters like pH, electrical conductivity, Total Dissolved Solids, nitrates, chlorides, and sulfates were found to be within the permissible limits of WHO. The values of temperature revealed were above WHO limits which basically ensured promotion of the growth of coliforms.

A substantial amount of decline in the microbial contamination i.e. 100% and in the turbidity level i.e. 91% was achieved at the exit of both treatment plants and it was found that the overall turbidity removal efficiency of SG-WTP is comparatively better than that of SM-WTP. Some recommendations were also given to upsurge the efficiency of the treatment plants like fencing of canals to avoid the grazing of animals, pre-chlorination of water to discourage the growth of fungi and bacteria, installation of de-sludge pumps, regular water quality monitoring and proper maintenance of treatment plants.

3.5 Policy Implications

3.5.1 National Drinking Water Policy

According to this policy, drinking water is referred as the water used for domestic purposes including drinking, cooking, hygiene and other domestic uses. The term safe water was added in compliance with National Drinking Water Quality Standards. According to the policy, access of at least 45 and 120 liter per capita per day of safe drinking water should be available for rural and urban areas, respectively.

Goal and objectives
Some of the main objectives of the Policy are as follows:
- Provide access to safe and sustainable drinking water supply to the entire population of Pakistan by 2025
- Ensure protection and conservation of water resources and promote measures for treatment and safety of drinking water
- Encourage community participation and empowerment in planning, implementation, monitoring and operations and maintenance of water supply systems
- Promote cost effective and appropriate technological options for water supply Systems
- Increase public awareness about water safety, safe hygiene practices and water conservation
- Enhance capacity of line ministries, departments, agencies and organizations at all levels in planning, implementation and monitoring of water supply programs and sustainable operation and maintenance of water supply systems

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• Promote public-private-partnership for enhancing access of safe drinking water and sustainable operation and maintenance of water supply systems and promote research and development for enhancing access, effectiveness and sustainability of water supply interventions
• Promote Inter-sector collaboration to maximize the impacts of water supply Interventions

3.5.2. Policy principles

The key policy principles that will be pursued for implementation of the Policy are as follows:
• Access to safe drinking water is the basic human right of every citizen and that it is the responsibility of the Government to ensure its provision to all citizens
• Water allocation for drinking purposes will be given priority over other uses
• In order to ensure equitable access, special attention will be given to removing the existing disparities in coverage of safe drinking and for addressing the needs of the poor and the vulnerable
• Recognizing the fact that women are the main providers of domestic waters supply and maintainers of hygienic household environment, their participation in planning, implementation, monitoring and operation and maintenance of water supply systems will be ensured
• Responsibilities and resources will be delegated to local authorities to enable them discharge their assigned functions with regard to provision of safe water supply in accordance with Local Bodies Legislation
• Implementation and monitoring
• The implementation and monitoring of the Policy, coordinated by the Ministry of Environment in collaboration with Provincial, AJK, FANA and FATA Governments include the following measures:
  • Comprehensive strategies and action plans for the implementation of policy will be developed
  • Necessary funds will be allocated
  • Submission of bi-annual progress reports of the planned strategies and actions to the Ministry of Environment
  • Implementation and monitoring of the policy in conjunction with the National Sanitation Policy will be ensured
• The Policy will be reviewed and updated after every five years by a committee constituted specially for the purpose of reviewing the implementation of its guidelines, their efficacy and continued relevance to the changing situation in the country.

3.5.3. Punjab Drinking Water Policy

The Government of the Punjab is responsible to ensure provision of safe drinking water for the entire population of the Province. It is, therefore, committed to create an enabling environment for the drinking water sector to ensure reliable, sustainable and affordable drinking water to its growing population. The “Punjab Drinking Water Policy” basically addresses the institutional, administrative, legal, regulatory, fiscal, social & environmental issues and challenges faced by both its rural and urban population. It provides guiding principles under which the efforts of provincial and local authorities shall be planned and coordinated. To keep the policy framework in line with the aims of the Federal Government, the Government of Punjab has adopted the key principles outlined in the National Drinking Water Policy of 2009.

Policy principles:

The key policy principles to be highlighted are as follows:
• Water being a finite and essential resource, needs to be regulated, managed and measured in order to avoid wastage and misuse.
• Drinking water allocation, saving surface and underground water aquifers from any kind of pollution and increasing public awareness will be given top priority through legislation / regulation.
Resource allocation for provision and conservation of drinking water will be aimed at creating an equitable distribution between urban and rural Punjab areas where the needs for drinking water are more than the actual supply.

- Rural community will be organized and provided with administrative, technical and financial backup in order to operate and maintain rural water supply schemes effectively.
- Public service provision institutions like WASAs, TMAs and others will follow a reform program which will be based on rationalization of tariff, reduction of ineptitude cost and improvement of service delivery.
- The private sector and non-governmental organizations will be encouraged to develop and implement service delivery models, in accordance with the objectives and principles of this policy.

**Objectives:**

- The key objectives of the policy to achieve the vision include:
  - Improving the standards of the public health through provision of improved services backed up by a legal, regulatory and binding framework.
  - Laying down a roadmap for mobilization of the resources required to ensure provision of drinking water to all with special priority to underserved areas of Punjab.
  - Focusing on the capacity building of local governments and Private-Public Partnership to improve the operation and maintenance of water supply schemes.
  - Mobilizing demand for improved water supply through a communication campaign, which takes cognizance of conservation, demand management, and contamination issues.
  - Facilitating the introduction and institutionalization of an effective Monitoring and Evaluation System, which includes performance benchmarking in service delivery.
  - Ensure protection and conservation of water resources.
  - Serving basis for the development of sector strategies, both for urban and rural water sector, to translate policy principles into action.

**Policy implementation:**

- Implementation of the strategies will be done by devoted sector programs and projects. These program and projects will be financed by the Provincial Government directly or through donor’s collaboration.
- WHO Water Quality and Health Strategy 2013-2020
  - WHO has adopted this strategy to maintain water quality with a view of protecting and promoting human health. This strategy is built on the basis of WHO water quality guidelines, MDGs, the human rights to water and sanitation. The strategy basically aims to attain the highest possible reduction in waterborne and water-related diseases by providing up-to-date, evidence-based guidance and coordination, and support for water, sanitation and hygiene interventions. To fulfill this mission, this strategy includes five major strategic objectives and their relative outputs:
    - Obtain the most rigorous and relevant evidence regarding water quality and health
    - Provide up-to-date, harmonized water quality management guidelines and supporting resources
    - Strengthen capacity of Member States to most effectively manage water quality to protect public health
    - Facilitate implementation of water quality and health activities through partnerships and support to Member States
    - Monitor the impact of these activities on policies and practice to more effectively inform decision making

**Outcomes**

- Reliable, up-to-date technical and policy advice on water quality management, informed by research conducted on water quality and health
- Increased number of countries with effective water quality policies and regulations that support preventive risk management of drinking-water, wastewater and recreational water and harmonized management of water-related hazards and risks

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• Improved risk management and risk communication practiced by all stakeholders responsible for water safety
• Effective networks and collaborations supported and strengthened to exchange resources, raise awareness and respond to specific water quality and health issues
• Implementation of Strategy
• Network of the strategy will be expanded by creating additional partnerships with NGOs in order to make the strategy strengthen in terms of both financial and human resources.
• WHO will coordinate with counterparts in the WHO Regional Offices and Country Offices to ensure needs of safe drinking water of Member States are being met.
• An expert group will be established that advise the Secretariat both on technical issues and on implementation and monitoring of this strategy, including the harmonized approach to water quality management.
• The networks and WHO Collaborating Centers will identify emerging issues related to water and health and will provide appropriate recommendations and also help in the implementation of work plan.
4. STUDY FINDINGS

4.1 Landscape of the Filtration Plants

Filter units are selected for sampling by keeping in mind their approach for the whole public having better design and landscape. All the surveyed filter units have almost the same design but their landscapes were different. Some of the filtration plants like I-10 Markaz, I-8/3, I-9/1, G-7/3, F-6/1, and F-10 Markaz units are located in very dense areas with shops, buildings, masjids and busy roads around the plants. The remaining filter units of I-10/4, G-10/2, G-11/2, and G-11/3 are situated at the places with relatively less population and buildings nearby, normally at the edges of huge grounds.

All the filter plants are designed and constructed in the same way but with little differences in the structure. All the filter units are built in the form of a cubicle, covered with white marble floors. These plants have enough taps approximately 6 to 8 in each unit so that the consumers do not have to wait for a long time by standing in long queues in case of less taps. There is a small control room at the back of each filter unit where the filters are placed and are controlled and looked after by managers. Moreover, these filter units have huge printed boards hanged over their tops with “Drinking Water Filtration Plant CDA” written on them.

One major difference to be observed in the filtration plants is the presence of a cement slab. All the filter units contain cement slabs except I-10/4, I-10/1 and G-10/2 filter units. Cement slab is basically a vertical solid support approximately 2-3 feet long. It is made up of cement, covered with marble and lies just below the taps. These slabs are beneficial in a way that they provide a support where the consumers can place their bottles and cans near the taps’ mouths, prevent splashes of water and allow the consumers to take water effortlessly without bending their backs.
4.2 Environmental Conditions around the Filtration Plants

Environmental conditions typically include type of soil, pollution, vegetation, population and climate in an area. The environmental conditions of the filtration plant depend upon the landscape and topography of the area where it is located. In case of field survey of filtration plants in Islamabad, different environmental conditions have been observed.

At the visit to the first filtration plant of I-10/4, worst conditions were observed. The plant was partly un-operational as there was only a single tap which was serving for water needs of the residents and a constant leakage from other taps has created a pool of stagnant water. There was an intense growth of wild herbs and shrubs around the unit. According to the residents, even that place was not safe for them because of the sudden attacks of pigs from the back wild growth of trees.

The filtration plants of I-8/3, I-9/1, I-10 Markaz and F-6/1 are located on busy roads, where there are more chances of pollution around the plant. These plants have a good proportion of vegetation around it but the unconcerned behavior of the dwellers has led to adverse environmental conditions. There are huge garbage piles in the surrounding area which have become breeding grounds for flies, insects, mosquitoes etc. Moreover, these areas are murky because of the dust and pollutants released by passing by automobiles.

Most worst environmental conditions were observed at the filtration plants of G-10/2, G-11/3 and G-11/2. These plants are situated at the end of huge grounds. Because of relatively less inhabited and less in use by the public, these filter units are being go unnoticed by the concerned authorities. Their white marble floors are changed into greenish brown because of extreme growth of algae and fungi. These filter units also faced extreme shortage of water especially in summers. The main reason may be the dense heavy growth of vegetation around the plants especially in the case of G-11/2 and G-11/3 which have made them obscured from the sight of passersby.

During the whole survey, the two filtration plants in better environmental conditions are G-7/3 and F-10 Markaz filter units. Though they are situated on busy roads but surprisingly the environment around them was much healthier and improved. The presence of a masjid in front of the G-7/3 filter unit may be the reason for good environmental conditions, but the cleaned white floors and taps in their relative positions showed the concerned behavior of the locals.
4.3 Users’ Response

- Consumption of filtered water

Islamabad is a modern and well-organized city sited in the Potohar Plateau; the northeastern part of the country. It is alienated into a number of different sectors and zones hence designated as the most developed city of Pakistan. People living in Islamabad are provided with all basic necessities of life i.e. food, shelter, water, education & health. Water being the basic requirement of every citizen is provided through a main pipeline in Islamabad which then yields to smaller pipelines to provide water to every household.

The preference of filtered water is significant due to its better quality. This is because people consider that the water supplied through pipelines and tube wells is unsafe for drinking purposes and they are of the perception that tap water is either contaminated or not treated to drinkable standards. The graph below clearly illustrates the usage of filtered water by approximately more than half of the population Islamabad.

![Choice for Filter Water](image1)

Figure 12. The figure shows the choice of people of Islamabad for the filtered water.

This high preference of filtered water is also because of the capability of filters to remove contaminants and other infectious agents from the water efficiently. The infectious agents vary in size, from large parasitic cysts to smaller bacteria and viruses. Thus, working of filters depends greatly on the physical size of the pores in the filter medium providing immediate access to drinking water without adding an unpleasant taste.

The survey shows that 89% of people always utilize filtered water which shows that it is considered safe for drinking purposes.

![Use of Filter Water by households](image2)

Figure 13. The figure shows the percentage of people that utilize the filter water.
Quality Analysis

Water purification is the method of changing unsafe drinking water to potable water. Water acts as a good solvent which makes it relatively difficult to purify without treatment. The common techniques used in purification of water are boiling, distillation, ion exchange and carbon adsorption etc.

Water quality can be apparently assumed from the smell, taste and color of water that shows how much the water is purified and capable for drinking purposes. In Fig.15, most of the people appeared satisfied with the smell of the water in different sectors of Islamabad. The highest percentage of people viewed disappointed with the smell of the water were in sector I-8/3 Islamabad.

Figure 14. The bar chart shows the percentage of people who experienced smell in filtered water from subsequent filtration plants in sectors of Islamabad.

Fig.15 shows the percentage of people satisfied with taste and color of water. The chart shows that almost half of the population being questioned seemed satisfied while the remaining residents are disappointed.

Figure 15. The bar diagram shows the satisfaction of respondents with color and taste of filtered water.
If taste or odor occurs at every water outlet then the cause is probably the main water supply. If it occurs only in certain faucets, the problem is the fixtures or pipes supplying those specific faucets. If the problem goes away after running the water for a few minutes, the problem is somewhere in the plumbing system.

- **Probable Causes of Low Quality Water:**

There may be different causes of odor found in water:

**Petroleum, gasoline, turpentine, fuel, or solvent odors:**
These odors are rare, but potentially serious. A leaking underground storage tank may be contaminating the water supply.

**Metallic taste:**
Minerals, such as iron or copper, may leach into the water from the pipes. Less common metals, such as zinc and manganese, could also be a problem.

**Chlorine, chemical, or medicinal taste or odors:**
Adding chlorine to the water or the interaction of chlorine with a build-up of organic matter in the taps or plumbing system may cause the taste or odor to be strong.

**Sulfur or rotten egg odor:**
Bacteria growth in sinks and taps causes this type of odor. Naturally occurring hydrogen sulfide in water supply may also be the cause.

**Moldy, musty, earthy, grassy, or fishy odor:**
Bacteria growing in a sink drain or from organic matter such as plants, animals, or bacteria that are naturally present in lakes and reservoirs may cause odor.

**Salty taste:**
High levels of naturally occurring sodium, magnesium, or potassium may cause a salty taste.

- **Further Treatment of Water by Consumers:**

The people who experience any smell, taste or color in the filtered water opt for further treatment of the filtered water before using it for drinking purposes. In Figure 16, 82% of people are using the filtered water directly showing the satisfaction of individuals about the quality of filtered water. 18% used filtered water after further treatment.

![Figure 16. The pie chart shows the percentage of people using filtered water directly without any further treatment.](Image)

For further treatment, boiling is the most common method recommended by health officers especially in the third world countries where their source of drinking water is not safe. Moreover, a study shows that water boiled for three minutes kills bacteria making water safe for drinking purpose. However, prolong boiling also presents some disadvantage as it concentrates inorganic impurities such as nitrate and sulfates. Water that undergoes heating process also tastes flat because the carbon dioxide is removed.
Fig. 17 shows that in the current study, about 84% of the people use boiling technique to further purify filtered water before using it for drinking purposes. This also shows that most of the consumers are also unaware of adverse effects of boiling.

![Methods Used For Further Treatment](image)

**Figure 17.** The pie chart shows the percentage of people using the process of boiling for further treatment of filtered water before usage.

Shortage of water is also faced especially in summers at almost all the surveyed filter units. In extreme summers in Pakistan, the natural water cycle gets disturbed which in turn increases the pressure on water resources. Due to decline in water bodies, the inflow water to the filtration plants also decreases. Water shortage also occurs due to the interruption in water supply by load shedding. It is obvious from the graph below that almost all the surveyed filtration plants in Islamabad suffer severe water shortage in summers.

![Water Shortage In Summer Faced By Sectors Of Islamabad](image)

**Figure 18.** The bar graph shows the percentage of people facing water shortage in summers in different sectors of Islamabad.

One fortunate thing to be noticed was that about 84% of the consumers haven’t faced any type of water borne disease. But according to some users’ response, their children have suffered from water borne diseases like diarrhea, cholera, dysentery and others. Such cases were rare and only observed at those plants where the filters were used for a long duration and thus causing deterioration of filtered water quality. If filters are not timely changed, they begin to harbor contaminants. If filters are not monitored regularly, they begin to grow mold especially in humid conditions. These molds do not only make the water taste bad but can also be ingested by the consumers leading to serious effects.
Active feedback:
During the survey analysis, the respondents presented an active feedback regarding the improvement in water quality and surrounding conditions. Most of the people of Islamabad are aware about what steps should be taken in order to improve the quality of filtered water. Many different responses were encountered in which the most common to be observed was that there should be regular maintenance of filtration plants which include timely change of filters, regular wiping of plants’ floors and walls, replacing broken taps etc. Chlorination, distillation, disinfection, desalination and use of activated carbon are some of the methods recommended by the people to improve filtered water quality.

Figure 19. The chart shows the percentage of people facing water borne diseases

Figure 20. Graph shows the types of water borne diseases faced by the consumers
The environment of most of the filtration plants is not healthy as there were garbage heaps all around which serve as breeding habitats for flies, cockroaches and rats. Stagnant water in front of each plant and wrappers of edibles in the filter units were common observations, showing the unconcerned behavior of the authority and the people. But when inquired from locals about what improvements should be made in surrounding area of the plant, all the visitors eagerly gave their opinions. Different responses were noted in which the maintenance of hygienic conditions of the plants was most common as shown in the graph below. Others include regular clearing of garbage, installment of garbage cans near the plant, responsible behavior of concerned authorities etc.

CDA is responsible to safeguard the health and security of the public by ensuring the provision of clean drinking water to them. Along with the concerned authorities, public should keep regular notice and take actions on their own to make the environment of filtration plants healthy and protective. But in extreme cases when the conditions become miserable, it is also the duty of the public to complain the authorities (CDA) as they are responsible for the regular maintenance and development of the filtration plants.

In the current study, a high percentage of people have never tried to complain to CDA regarding poor hygienic conditions of the filter plant; mainly because of lack of sense of responsibility and lack of awareness. But those who complained gave very frustrated responses as their phones have never been picked up. Most of the users were quite unsatisfied with the hygienic conditions of the filter plants while only 16% of total were satisfied as shown in figure 25. Muddy floors with deposition of fungi algae, broken taps, and garbage heaps all around were common in most of the filtration plants.
### 4.4 Water Quality Assessment

The quality of water provided by the filtration plants is affected by different factors like operational capabilities of filters, chemical parameters, microbiological factors, landscape of filtration plants etc. Moreover, it is also greatly influenced by the inflow water of the filtration plant i.e. the main source from where the water is provided. In case of filtration plants installed in Islamabad, the major sources are dams, tube wells and sumps. The water source of each surveyed plant in the current study is given in the table below:

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I-10/4</td>
<td>Tube Well no.71</td>
</tr>
<tr>
<td>2.</td>
<td>I-10 Markaz</td>
<td>Sump</td>
</tr>
<tr>
<td>3.</td>
<td>I-9/1</td>
<td>Tube Well no.140</td>
</tr>
<tr>
<td>4.</td>
<td>I-8/3</td>
<td>Sump</td>
</tr>
<tr>
<td>5.</td>
<td>G-10/2</td>
<td>Nil</td>
</tr>
<tr>
<td>7.</td>
<td>G-11/3</td>
<td>Tube Well no.100</td>
</tr>
<tr>
<td>8.</td>
<td>F-10 Markaz</td>
<td>E-10 Head Works</td>
</tr>
<tr>
<td>9.</td>
<td>F-6/1</td>
<td>Tube Well no.193</td>
</tr>
<tr>
<td>10.</td>
<td>G-7/3</td>
<td>Tube Well no.61</td>
</tr>
</tbody>
</table>

Table 4. Shows the main water sources of surveyed filtration plants in Islamabad

The permissible limits are taken from PSQCA\(^{11}\) and Pakistan EPA\(^{12}\) reports.

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\(^{12}\)
4.4.1 Microbiological Analysis

4.4.1.1 Ecoli

Ecoli is also known as escherichia coli which is a gram-negative, facultative anaerobic and rod-shaped bacterium. It is commonly found in intestinal track of humans. The main sources of Ecoli in water are human and animal fecal waste discharged directly into water bodies.\textsuperscript{13}

In the current study, it is found that the water samples of all filtration plants are free from Ecoli, as the water analyzed before and after the filtration process shows no sign of contamination. But the condition of filters cannot be determined from these results. It cannot be concluded that whether the UV disinfection systems installed at the filtration plants are working properly or not.

![Ecoli Graph](image)

Figure 25. The graph shows the amount of Ecoli in the water of filtration plants of subsequent sectors of Islamabad.

4.4.1.2 Total Coliforms

Coliform bacteria are common in soil and vegetation and are generally harmless. However, their detection in drinking water indicates the presence of pathogens that mainly come from the feces of humans and animals. WHO establish standards for coliform bacteria in drinking water are zero total coliform per 100ml of water. If total coliforms are detected, the problem can be resolved by searching for the source of contamination and take appropriate measures to restore safe drinking water.\textsuperscript{14}

Based on the standard, following analysis can be drawn:

The pre and post treated water samples from the filtration plants of G-7/3, G-10/2, G-11/2, G-11/3 and F-10 Markaz show no sign of contamination before and after filtration. From such results, the functionality of UV disinfection systems installed at these plants cannot be determined that either they are eliminating the infectious agents from water efficiently or not.

Water provided by the filtration plants of F-6/1 and I-8/3 is not safe for drinking as it is highly contaminated with total coliforms. The analyzed number of total coliforms in water remains the same before and after filtration in F-6/1 filtration plant while in I-8/3 plant, the amount of coliforms becomes

increased after filtration. The UV disinfection systems installed at these plants totally out of function and have not been changed for long.

The UV disinfection systems of I-10/4, I-10 Markaz and I-9/1 filtration plants reduce the number of total coliforms from water as shown in the graph below and give much better results than the systems installed at other plants. But these disinfection systems are also not capable of providing completely coliforms free water to consumers. The UV disinfection systems of these plants need to be upgraded regularly.

**Figure 26.** The graph shows the total coliforms in the water of filtration plants of subsequent sectors of Islamabad.

The results discussed above shows that the different systems installed in the filtration plants are not working which demonstrates the presence of total coliforms in the filtered water.

**4.4.1.3 Fecal coliforms**

Fecal coliform bacteria are a subgroup of coliform bacteria. The presence of fecal coliform in a drinking water sample indicates that there is a greater risk of pathogens in water. Their contamination is a result of any problem in water treatment or in plumbing. Consumption of microbiologically contaminated water can cause diseases like diarrhea, nausea, cholera etc. WHO establish standards for fecal coliform bacteria in drinking water are also zero fecal coliform per 100ml of water.

The lab results of present study show that the number of fecal coliforms at filtration plants of sectors G-7/3, G-10/2, G-11/2, G-11/3, F-6/1 and F-10 Markaz remains same in pre and post treated water. This does not relate to the working condition of the filters mounted, as it cannot be said whether the UV disinfection systems installed at these plants are working or not because the pre-treated water also shows the absence of fecal coliforms.

Interesting results are seen at the filtration units of I-8/3 and I-10 Markaz where the UV disinfection systems removed all the fecal coliforms from the filtered water. The UV system of I-10/4 also reduced the number of fecal coliforms to much extent as shown in the graph below but is not upgraded to eliminate fecal coliforms completely.

Much disappointing result is observed at the filtration plant of I-9/1 where the UV disinfection system is in such a despondent condition that it leads to increase in the number of fecal coliforms after the water being passed through it. Such a system needs to be changed instantly to avoid any adverse effects of heavily contaminated water on consumers’ health.

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4.4.2 Chemical Analysis

4.4.2.1 Electrical Conductivity

Electrical conductivity value of a water sample gives a general impression of the concentration of dissolved ions of alkalis, chlorides, sulfides and carbonate compounds in it. Electrical Conductivity will be higher for water that has dissolved more ionic species in it. Generally there is no health standard for conductivity but EEC (European Economic Commission) has set a guide value for conductivity which is 400μs/cm at 20°C. Different values of electrical conductivity are recorded from analysis. All the obtained values of pre and post treatment water samples are higher than the guide value set by EEC. The analysis is categorized as following:

- The filtration plants with water samples having same values of electrical conductivity as before filtration process are located in F-10 Markaz, G-11/3 and F-6/1. The pre and post treatment water samples of these plants have same values of electrical conductivity. This may be the hindrance in the functionality of filter systems installed at these plants, as they are not more useful in removing dissolved ionic species and need to be regulated.

- The filtration plants with water samples having increased values of conductivity after filtration are in G-10/2, I-9/1 and I-8/3 sectors. Here, the post treatment water samples have higher values of conductivity as compared to those of pretreated samples. This may be due to dysfunctional filter systems installed there which have lost their capacity to eliminate contaminants which results in increased concentrations of dissolved ions in the filtered water. Moreover, the trapped contaminants in such filters started to leak and increased conductivity of filtered water.

- The filtration plants with water samples having reduced conductivity after filtration are of I-10 Markaz, G-7/3, G-11/2 and I-10/4 sectors. The conductivity values of these water samples become decreased after filtration but they still lie above the guide value set by EEC. This shows that the filter systems of these plants are somehow working but still they need regular maintenance and improvement.
4.4.2.2 pH

The role of pH is associated with the corrosion, hardness, acidity, chlorination, coagulation and alkalinity. The pH does not have a direct impact on human health but a standard range is being suggested by PSQCA for drinking water that is 6.5 to 8.5. It may be affected by naturally occurring minerals of calcium, magnesium and iron in the water resource, faulty plumbing, corrosion, rusty pipes and taps and also from fungus growth on them. In case of lower pH, water softeners can be added or neutralizing filters containing calcium carbonate can be used to increase pH to drinking standards. While in case of higher pH, water is treated with acids most often with citric acid and alum which also improve the effectiveness of chlorination and also reduces the potential of pipe corrosion.

According to the results of the present study, the pH values of pre and post treatment water samples of all filtration plants lie within the standard range. The maximum pH value of 7.78 is observed at filtration plant of F-10 Markaz while minimum pH of 6.93 is found at I-9/1 filtration unit. So, the filtered water having standard pH if fit for consumption.
4.4.2.3 Nitrates (N)

Nitrates naturally occur in surface and ground water but high levels of nitrate in water mainly result from overuse of chemical fertilizers, wastes from septic systems, animal feedlots, industrial and food processing activities. Excess amount of nitrates in water tends to stimulate algal growth and indicate possible eutrophic conditions. Therefore, a standard limit is set by PSQCA (Pakistan Standard Quality Control Authority) which is 10mg/L for drinking water. The values observed in the present study after analysis were all below the standard value but the difference lie on the operational capacity of the filter systems working there.

- The filters installed at the filtration plants of G-11/3, F-6/1, F-10 Markaz, I-10/4 and I-8/3 are in such a despicable condition that their efficiency to remove nitrates from water has become limited. The pre and post treatment water samples are analyzed to have same number of nitrates. The reason may lies in the functionality of technologies involved in removing nitrates from water like reverse osmosis and ion exchange method. The standard pressure of 150 psi needs to be maintained and the resins involved in ion exchange need to be charged regularly for effective nitrate removal.

- The filtration technologies installed in I-10 Markaz, I-9/1 and G-7/3 plants have become totally outdated. The filtration process leads to increase the amount of nitrates in post treated water as shown in the figure below. These filter systems need immediate replacement from new ones as they may increase nitrate level above the standard limit in filtered water.

- The water samples obtained from G-11/2 and G-10/2 plants after filtration have reduced amount of nitrates which shows better operational capacity of filters than others.

![Figure 30. The figure shows the nitrate ions concentration in water of filter plants of Islamabad.](image-url)
4.4.2.4 Sulfates

Sulfate naturally occurs in almost all water. Other sources may include oxidation of sulfite ores, the presence of shale and industrial wastes. The presence of sulfates in water supplies is mainly because of dissolution of sulfate containing mineral rocks (sodium sulfate and calcium sulfate) and soils into water sources. Health concerns regarding sulfate in drinking water are increasing because of many diarrhea cases reported from the consumption of water containing high levels of sulfate. Therefore, PSQCA has suggested a maximum level of 250mg/L of sulfate in water intended for human consumption. Fortunately, all the analyzed values of pre and post treatment water samples of current study lie below the standard level of 250mg/L. The analysis is characterized on the basis of working capacities of filtration systems.16

- Much disappointed results are observed where only 2 out of 10 filtration plants i.e. G-11/2 and G-7/3 have installed filters that are capable of removing sulfates from water. Filtration technologies of reverse osmosis and distillation need to be regulated and improved in order to pace their operations and to achieve required results.

- The filters installed at filtration plants of I-8/3, I-9/1 and G-10/2 have completely lost their function to remove sulfates from filtered water. Instead they lead to increase in the amount of sulfates after filtration. These filters need to be changed instantly.

- The filtration systems of I-10 Markaz, F-10 Markaz, I-10/4, F-6/1, and G-11/3 plants are also not working properly. The results obtained before and after filtration are same as seen in the figure below with same amount of sulfates in pre and post treated water. This may be due to a damaged membrane in reverse osmosis or the resins involved in ion exchange method have become fully charged with ions which cease the treatment. So, there is a need to recharge their limited functions.

Figure 31. The graph shows the sulphate ions concentration in filtered and un filtered water of sectors of Islamabad.

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4.4.2.5 Calcium

Calcium is common in surface and ground water as Ca$^{2+}$. The abundance of calcium in seawater is mainly due to its natural occurrence in earth’s crust. When there are high deposits of calcium containing minerals like limestone and dolomite in water, hard water is formed. Moreover, calcium is an important determinant of water hardness, and it also functions as a pH stabilizer, because of its buffering qualities.\(^\text{17}\)

Hard water is generally not harmful for human health but it poses serious problems in industrial settings. A standard limit is given by PSQCA for calcium in drinking water which is 100mg/L. According to the standard, values of all pre and post treated water samples lay below the limit except for the values of pretreated water of G-11/2 and post treated water of I-9/1 and I-8/3 which are higher than the standard. According to the results shown in the figure below:

- Filtration plants of F-10 Markaz, F-6/1, G-11/3, and I-10/4 provide filtered water with the same quantity of calcium present as before filtration process. The capability of the installed filters has become limited to stabilize calcium amount in filtered water. These filters need to be improved by boosting water softeners which act as ion exchangers to remove calcium.

- Filtration systems of I-10 Markaz, I-9/1 and I-8/3 plants provide very dissatisfied results as the amount of calcium increased after filtration. The graph clearly illustrates that the level of calcium becomes much higher than the standard level in post treated water from I-9/1 and I-8/3 filtration plants. This increase is mainly due to drainage of residual calcium from outdated and dysfunctional filters which have not been changed for long.

- Only filtration plants of G-10/2, G-7/3 and G-11/2 sectors are able to reduce calcium quantity in filtered water. One thing to be noted that pretreated water of G-11/2 filtration plant contains much higher amount of calcium i.e. above the standard level, than other plants. This increased quantity is related to the water source of that filtration plant, which contains high deposits of calcium containing minerals.

![Graph showing concentration of calcium ions in pretreated and post treated water of filtration plants of Islamabad.](image-url)

Figure 33. The graph shows the concentration of calcium ions in the pretreated and post treated water of filtration plants of Islamabad.

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4.4.2.6 Magnesium

Magnesium is one of the most commonly found cation in oceans. It is also found in rivers, marine algae and oysters. Other sources of magnesium in water include chemical and fertilizer industries, cattle feeds and uses as flocculants in wastewater treatment plants. High concentrations of magnesium constitute hard water, which is generally not harmful to human health. To avoid any serious impacts, a standard level of 50mg/L is set for magnesium in drinking water. According to the standard, all water samples analyzed in the current study contain standard amount of magnesium. Following analysis can be drawn from the results:

- The pre and post treated water obtained from F-10 Markaz, G-11/3 and F-6/1 filtration plants have same values of magnesium. The filters installed there are not working properly and need proper maintenance and improvement. Moreover, water softening used to remove magnesium need to be boosted.

- The post treated water contains increased amount of magnesium as compared to pretreated water in I-10 Markaz, G-11/2, G-10/2 and G-7/3 filtration plants. The filters installed there are totally out of function and they need to be replaced immediately by new ones.

- The post treated water contains reduced amount of magnesium as compared to pretreated water collected from the filtration plants of I-8/3 and I-9/1. These filters are operating properly and are capable to stabilize magnesium amount in filtered water.

![Figure 33. The graph shows the concentration of magnesium ions in the pretreated and post treated water of filter plants of Islamabad.](image)

The graph shows the concentration of magnesium ions in the pretreated and post treated water of filter plants of Islamabad.
4.4.2.7 Sodium

Sodium naturally occurs in seawater and freshwater in the specific amount of 11,000 ppm and 9ppm respectively. Other sources of sodium in water include metallurgy, nuclear reactors, and fertilizers. Sodium is also used in the treatment of water such as in water softening; excessive calcium and magnesium are replaced by sodium ions in water.\(^\text{18}\)

Sodium must be present in a specific quantity in water. Consumption of water containing very low sodium results in hyponatremia in humans while high sodium level affects the taste of water. A standard level of 50mg/L of sodium in drinking is set by PSQCA according to which all analyzed values of sodium in the present study are below this limit. Following points can be analyzed from the graph shown below:

- The amount of sodium in pretreated water is equal to the amount present in post treated water in G-11/3, F-6/1, F-10 Markaz, I-9/1, and I-10/4 filtration plants. This shows that filters installed there are not working properly. Their function of removing sodium from water has become retarded that’s why the concentration of sodium remains unchanged in filtered water.

- The amount of sodium in post treated water becomes increased from the amount present in pretreated water in the filtration plants of I-8/3 and G-10/2. This increase has surpassed the standard value in G-10/2 plant. It may be due to old and outdated filters installed there from which the residual sodium has started to washout or due to water softeners which are used to reduce ions from water by replacing them with sodium ions.

- The amount of sodium in post treated water becomes decreased from the amount present in pretreated water in the filtration plants of G-11/2, I-10 Markaz and G-7/3. This shows that properly operating filters are installed at these plants which are able to maintain the adequate amount of sodium in filtered water.

![Graph showing sodium concentration in filtered and unfiltered water](image)

Figure 34. The graph shows the sodium ions concentration in the filtered and unfiltered water of Islamabad sectors.

4.4.2.8 Potassium

Specific amounts of potassium are present in sea water and in rivers i.e. 400ppm and 2-3 ppm respectively. Moreover, it is present in various minerals like feldspar from which it may be dissolved in water through weathering process. Potassium is usually found in the ionic form and the salts are highly soluble. Other sources of potassium in water include industries, photography, tanning, detergents, and softeners. Potassium is considered as a dietary requirement for almost all organisms therefore 10mg/L of potassium is set as a standard limit in drinking water.

In this study, water samples obtained from all surveyed filtration plants contain potassium below the acceptable limit but with different operational competences of filters installed there.

- Filters installed at F-10 Markaz, F-6/1, I-10/4, G-11/2 and G-11/3 filtration plants have no effect on potassium content of pre and post treated water. The amount of potassium remains constant before and after filtration. These filters may have become outdated and need regular maintenance or they may be operational having no effect on such small amount of potassium present in water.

- Some filters lead to increase in potassium content of water after filtration like in case of I-9/1, I-10 Markaz and G-10/2 filtration plant. The main reason of such slight increase in potassium amount in water is the use of water softeners containing potassium for manganese removal and disinfection. In the case of high potassium content in water, it can be effectively removed by the process of reverse osmosis.

- Filters installed at I-8/3 and G-7/3 filtration plants have caused a slight deceased in the amount of potassium in filtered water as shown in the graph. These filters seem to work properly and respond over even a small amount of potassium in water.

![Graph showing concentration of potassium ions in treated and untreated water of filter plants of Islamabad.](image)

Figure 35. The graph shows the concentration of potassium ions present in the pretreated and post treated water of filter plants of Islamabad.
4.4.2.9 Chlorides

Almost all natural waters contain chloride ions. Moreover, chlorides get into water from several other sources like wastewater from industries and municipalities, water softening, road salting, agricultural runoff and also produced water from gas and oil wells. In small amounts, chlorides are not significant but in large concentrations they cause a brackish, briny taste that certainly is undesirable. PSQCA has recommended a maximum concentration of 250mg/L for chloride ions in drinking water. All the chloride values for pre and post treatment water samples collected in this study are below the acceptable concentration. Further analysis is categorized as:

- Filters installed at F-10 Markaz, G-11/3, F-6/1 and I-10/4 filtration plants have no effect on chloride ions present in pre and post treated water. The chloride content remains same before and after filtration process. This may be due to limited functionality of reverse osmosis and distillation methods which need to be regulated.

- The filters installed at the filtration plants of G-10/2, I-8/3, I-9/1 and G-7/3 lead to increase in chloride ions of water after filtration. These filters may have become dysfunctional and lost their ability to absorb chloride ions or this increase may be due to the addition of chlorine additives used to control microbes.

- Filters installed at I-10 Markaz and G-11/2 filtration plants have caused reduction in the amount of chloride ions in filtered water as shown in graph below. These filters are working properly and provide filtered water after stabilizing the chloride content in it.

![Graph showing chloride levels](image_url)

Figure 36. The graph represents the concentration of chloride ions of filtered and unfiltered water of filtration plants of Islamabad.
4.4.2.10 Hardness

Water hardness represents aesthetic quality of water and is mostly caused by high constituents of minerals calcium and magnesium in water. The degree of hardness becomes greater as the calcium and magnesium content increases. Hard water is not a health hazard but according to PSQCA, its maximum acceptable level is 500mg/L in drinking water. Hardness in water can be minimized or removed by adding water softeners or by installing ion exchange water softening units which continuously remove excess amount of calcium and magnesium.

After the analysis of collected water samples for hardness, the result shows that both inflow and outflow water in all filtration plants contain hardness below the acceptable limit. But the installed filters deal with water hardness differently as:

- Some of the filtration plants like F-10 Markaz, G-11/3, F-6/1 and G-7/3 plants neither increase nor decrease the hardness of filtered water. The hardness remains constant in pre and post treated water samples as seen from the graph below.

- The filtration plants of I-10 Markaz, I-10/4 and G-11/2 are working properly, causing a decline in the hardness of water after filtration. This may also occur when managing other water quality parameters during filtration which ultimately results in the reduction of hardness.

- In filtration plants of I-8/3, I-9/1 and G-10/2 sectors, filtered water is found to be harder than pretreated water. The main reason to be considered is the discharge of trapped ions when the ion exchange units become fully charged.

![Figure 37. The figure shows the hardness of water of filter plants of Islamabad.](image-url)
4.4.2.11 Total Dissolved Solids

TDS is a secondary drinking water standard and is non-filterable residue and therefore is regulated because it is more of an aesthetic rather than a health hazard. TDS in water usually originate from mineral springs; carbonate deposits, salt deposits, sea water intrusion, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process, and the nature of the plumbing. A standard level is given for TDS in drinking water i.e. 1000mg/L because elevated level may cause the water to be corrosive, salty or brackish taste result in decrease efficiency of hot water heaters.

In the current study, all pre and post treated water samples contain TDS below the acceptable level. So, the water is fit for consumption and industrial activities. But the conditions of filters installed at the filtration plants can be assumed from the analysis below:

- No change is detected in the TDS values of pre and post treated water samples from plants of F-10 Markaz, F-6/1 and G-11/3. The most probable reasons may be installation of outdated filters or may be the filters are operational but have no effect on already standard TDS concentrations.

- The filtration plants of I-10 Markaz, I-10/4, G-7/3 and G-11/2 are operating effectively, causing reduction in TDS concentrations of filtered samples.

- An increase in TDS content is observed in filtered water samples collected from the filtration plants of I-8/3, I-9/1 and G-10/2 as shown in the graph. This directly points towards the deprived performance of filters installed there. Such filters need proper maintenance and improvement from concerned authorities.

Figure 38. The graph shows the level of TDS in pretreated and post treated water of filtration plants of Islamabad.
4.4.2.12 Turbidity

Turbidity is considered as a good measure of the quality of water. It gives a general impression of concentration of suspended particles in water. The more total suspended solids in the water, the more it seems murkier and the higher the turbidity. The sources of turbidity in water include sediments from erosion, waste discharge, algae growth and urban runoff. These suspended particles increase the temperature of water which can promote the growth of microbes. Therefore, WHO (World Health Organization) suggested that turbidity should not be more than 5 NTU and should ideally be below 1 NTU.

According to the standard, all analyzed water samples are considered ideal in terms of turbidity except the pretreated water sample from I-10 Markaz filtration plant, which contain maximum turbidity of 2.73 NTU. The analysis shows that:

- No change is detected in the turbidity of pre and post treated water samples in filtration plants of I-10/4, I-8/3, I-9/2, G-11/2, G-10/2 and F-10 Markaz. The value of turbidity remains zero before and after filtration. Hence, the efficacy of installed filters to standardize turbidity in filtered water is not assured.

- As shown in the graph, the filtration plants of G-11/2 and I-10 Markaz are providing completely turbid free water to the consumers.

- The filtration plants of G-7/3 and F-6/1 are not showing much satisfactory results. As in the former, turbidity increased while in the latter, turbidity remains same. The chances of hazard lie in the filters installed in G-7/3, which have become un-operational and instant regulation or replacement. Advanced techniques of coagulation, flocculation and sedimentation should be introduced prior to ion exchange method.

![Figure 39. The graph shows the turbidity of filtered and unfiltered water of sectors of Islamabad.](image-url)
4.4.2.13 Alkalinity

The alkalinity of water is an indication of the concentration of carbonate, bicarbonate and hydroxide, but may include contributions from borate, phosphates, silicates and other basic compounds. Carbonates and bicarbonates occur in water naturally and also due to addition of soda lime to soften the water. These compounds can be detected by their acrid taste in water.

Alkalinity of water samples collected in the present study depends on the concentration of carbonates and bicarbonates of the water source as well as on the working conditions of installed filters. Excessive alkalinity can be removed effectively by reverse osmosis, distillation and deionization.

According to the results, different values of alkalinity are obtained of pre and post treated water samples.

- As shown in the figure, the filtration plants of F-10 Markaz, F-6/1, G-11/3, I-10/4 and I-8/3 obtained the same values for alkalinity in filtered water samples as those of unfiltered samples.

- The values of alkalinity get increased in water samples after filtration in the filtration plants of G-10/2, I-10 Markaz and I-9/1. This shows the defective performance of filters installed. The main water supply of these plants may be more concentrated with carbonates and bicarbonates.

- The filtration plants of G-7/3 and G-11/2 have the ability to stabilize the amounts of carbonates and bicarbonates in water to maintain alkalinity.

![Graph showing values for alkalinity in pre and post treated water of filtration plants.](image)

**Figure 41.** The graph shows the values for alkalinity in pre and post treated water of filtration plants.
4.5 Constraints

**Lack of sense of responsibility:**
As the local residents of Islamabad, people had awareness that how important is safe water for their health. But they lack the sense of responsibility to take care of the resources provided to them.

**Lack of Concern by Authorities:**
The concerned authority that is Capital Development Authority (CDA) does not show any concern towards the filtration plants. The CDA does not concern for the upkeep and maintenance of the plants.

**Lack of labor**
The environment and conditions of the cities of Pakistan shows that there should be provision of security for every public and governmental property. There is lack of security guards and labor for cleaning the filter plants. This ultimately leads to the unhygienic conditions and loss of taps or destruction of the filter plants.

**Lack of regular maintenance of filters**
Bad conditions and demolition of filter plants shows the lack of regular maintenance by the concerned authorities i.e. CDA.

**Lack of management**
Poor management of the authorities is leading towards the ruining of the construction material of filter plants as well as the unsafe water quality. This may leads to serious health hazards among the residents of Islamabad.

**Lack of hygiene**
Hygienic conditions are necessary for the maintenance of good health as well as clean environment. The lack of hygiene in the filter plants yields in the growth of fungus on the taps as well as on filter. The fungus and algal growth would further result in the harmful water quality.

**Scarcity of filter plants**
As there are total 32 filter plants installed by CDA in Islamabad, out of which 28 are not operational. Some of filter plants have broken taps while some are destroyed by the recent construction of roads by the government. Some are being closed due to not changing of filters for a long period of time. This shows that the filter plants are less in number as compared to the population of Islamabad.

**Lack of media concern**
Lack of media concern may also be the reason for the ill conditions of filtration plants. Weekly or monthly articles regarding the protection of environment are not frequently published in newspapers or magazines for public awareness. Moreover, the responsibility of the media to highlight any misfortune, in the case of unconcerned attitude of CDA, is not being fulfilled sincerely. Awareness programs and plays on television are also not popular.

4.6 Issues and options available

**Managerial issues**
Different management issues and aspects mentioned below are commonly observed in the filtrations plants:

- Most commonly, there is a lack of proper leadership and managerial support is nowhere to be seen.
- There may be less number of staff available or low staff morale which in turn leads to inadequate maintenance practices.
- Lack of sufficient communication between staff can also lead to serious managerial issues.
- Poor communication can also lead to delay in the replacement of faulty equipment (filter, pipeline) which can have adverse effects on water quality and human health.
- Managerial issues also include poor working conditions for the staff which can enhance the risk of personal injuries.
It is the responsibility of the supervisor to keep checks on the functionality of the filters and the amount of chemicals or materials needed. But these responsibilities are normally not fulfilled.

**Options available**

Appropriate practices and measures should be taken in order to cope with the issues arising from poor management:

- Most importantly, the selected managers or supervisors should have that enthusiasm to serve the public in an honest way and to provide best working conditions for their employees.
- The staff appointed should have appropriate qualifications and experience related to water treatment and supplies.
- Proper planning of projects and water related resources, timely reporting of issues, and implementation of innovative technologies should be done with full participation of staff members in order to develop and enhance communication skills among staff.\(^{19}\)
- In order to prevent sudden failure of equipment or shortage of chemicals or materials, yearly and budgeted contracts should be made with the relevant industries.

**Technical issues**

Different technical issues being faced by the filtration plants are as follow:

- One of the major problems observed is that the designed capacity of the filtration plants in some areas is less than the actual demand. Furthermore creating shortage of water especially in summers.
- The common thing observed in most of the filtration plants was the absence of any storage facility for the filtered water. In extreme summers, load shedding and lack of any storage tank creates severe shortage of drinking water for the residents of Islamabad.
- Many filtration systems of Islamabad are old showing signs of deterioration. The pipes are corroded and ruptured. Many valves and couplings are leaking. These issues are neglected by the concerned authorities leading to the contamination of filtered water.
- The filters are used for long durations without being washed out or replaced by the new ones. This condenses the efficiency of the filters which can have adverse effects on the water quality.
- If dry summer season prevails, lowering of water table occurs due to constant drawn out from reservoirs. Thus, the water inflow to the plants can become less.

**Options available**

- When designing a plant, the capacity should be considered with sufficient storage facilities by analyzing the expected population growth and the number of water consumers\(^ {20} \)
- Filters should be frequently washed out in order to clean the dust particles collected in the filter media. But in the case when demand is high, it is better to replace the old filter by the new one.
- Filtration plants should be regularly visited and inspected by the concerned authorities (CDA) and the locals should also complain regularly about any fault in the filter unit. In this way, the authority will remain be active and all possible measures in the renovation of filter plant.
- Conservation of the water bodies should be considered very important and reforestation should be done in the crucial areas in order to prevent chances of water shortage.

**Social issues**

Some of the social issues faced are:

- There is a common observation of vandalism of public and private property, and terrorism from which the filtration plants are also no more secure.
- Pocketing of taps, pipes and motors by thieves and junkies is a common practice nowadays.

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Social issues also include the unconcerned behavior from the residents of the area and dumping of solid waste around the filter unit.

Lack of participation and involvement by public in decision making and implementation of decisions by the concerned authorities.

Lack of awareness among the public regarding the quality issues and the resulting water borne diseases.

Options available

- To avoid vandalism and pocketing of equipment, a plan should be formulated according to which a time will be set for the opening and closing of filtration plant otherwise it will be locked with the taps covered by structures made up of steal grids.
- In order to enhance awareness among the public, workshops can be arranged and pamphlets can be distributed which contain necessary information regarding health and environment issues.
- Management committee should promote active participation by public in the relevant issues and should also provide opportunities for the energetic members of the community especially youth to play their roles in conserving environment.

Development issues

A highly privileged city like Islamabad is also facing many water related issues:

- There are not enough filtration plants to fulfill the water needs of the entire population as some are destroyed and become un-operational due to constructional purposes.
- Some filtration plants are located in areas having dense growth of wild herbs and shrubs which are not in easy access for the public.
- Lack of sufficient taps might create hurdles for the consumers to get water along with wastage of time and energy.
- Unhygienic conditions are observed even in many operational filtration plants.
- The type of material used for distribution system (pipelines, valves, couplings) is corrode able and is not durable.

Options available

- A survey should be conducted to report the condition of all filtration plants to the concerned authorities so that they should take appropriate measures for the installment of further plants.
- At least each plant contains 8 to 10 taps, so that that the consumers do not have to wait for a long time by standing in long queues to get water.
- General cleaning of all equipment should be part of the daily duties and conducted under strict safety regulations by the authority.
- Installing new filtration plants and the selection of durable equipment should be cost effective.

4.7 Institutional Gaps

Capital Development Authority (CDA) is a public benefit institution in Islamabad established on June 14, 1960. It is responsible to execute all the functions related to health, social welfare, recreation, education, rehabilitation of persons with disabilities, population welfare, etc. CDA Board is basically comprised of the Chairman, Member Finance & Accounts, Member Administration, Member Planning & Design, Member Engineering, Member Environment and Member Estate.

In order to perform the functions efficiently, CDA has organized itself into six wings. These are Administration Wing, Estate Wing, Engineering wing, Finance wing, Planning & Design Wing and Environment Wing. Each wing further includes several directorates.

The directorate of Water Supply is included under engineering wing. This wing is responsible for production, treatment, conduction and distribution of potable water from different surface as well as ground water resources to the entire population of Islamabad. This wing has also ensured the provision of clean drinking water to the public by installing different filtration plants in each sector of Islamabad.

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But as water demands are increasing day by day, the more the responsibilities have been seen to be exempted by CDA. Many different policies and strategies related to the auxiliary improvement and development of the water supply schemes in the city exist but the only need is their effective and timely implementation which is mostly lacking in the performance of CDA.

Where some sectors of Islamabad are highly privileged with overdevelopment and with best available facilities to the residents while some are extreme underdeveloped like Golra and Mehrbadi where abandoned and dysfunctional schemes are present. This may be due to weak developmental and financial planning of CDA, as a result of which such backward areas are always being neglected.

Many cases and complains are reported to CDA by the public and other organizations, but the main reason considered for their negligence and delayed actions to be is the lack of coordination within the institution and with the community. Where there is insufficient communication within the authority, there will be no sharing of information which will lead to mismanagement and inadequate maintenance and regulation activities.

So, Capital Development Authority should increase its pace their efforts and take effective measures to improve its performance as well as water supply demands of the citizens of Islamabad including both privileged as well as under privileged sectors of the city.

4.8 Capacity Building Needs

Training and capacity building is the only way through which an institution can enhance its efficiency. Trained employees not only help boost the institution’s performance but also contribute positively towards the authority and its goodwill through their skills. Trainees are also considered to be the main source of expertise for the success of any project. Even though CDA has organized a Training Academy for its employees, but still there is a need to pace their efforts and to improve their potential. Moreover, there should be regular monitoring and evaluation of all the directorates and their projects. Regular monitoring will enforce all the projects to be timely implemented and ended and will eliminate any dysfunctional phase of the project whenever necessary. This will also encourage the formulation of such projects in the future.

There is also the need of effective communication and management skills among the employees of CDA. CDA can increase its capacity to a great extent by improving its coordination within the authority and with the public as well. Only then, they will be able to deal with the problems more genuinely and will allow the public to be aware of their personal responsibilities towards the betterment of the city.

4.9 Awareness and Mass Communication Needs

Increasing public awareness of environmental concerns, health and hygiene especially in underdeveloped countries like Pakistan, is a way through which the people can be allowed to play active roles in conserving the environment and making it healthy and productive. Awareness can be enhanced in a several ways like:

Environmental awareness campaigns are very successful in developed countries which help the people to understand how these problems are affecting their lifestyles. Such campaigns should also be organized in Pakistan. Moreover, environmental education should be included in the curriculum as a part of current science or as a separate discipline in schools so that children should be aware of the current problems in their country. Environmental documentaries and plays can also be prepared as one of the best ways to educate children and teens about environmental problems. This will also help them foster a sense of responsibility as they may be future environmentalists of Pakistan.

Media can play an active role in increasing awareness among the public. Environmental organizations can disseminate their message by holding press conferences on current problems, by distributing printed pamphlets in public or by setting up online databases which can be very helpful for people. Awareness programs, sessions or plays should be displayed on television. Printed media should also play its role by publishing articles and editorials written by environmental experts in newspapers and magazines. Such articles should be in common accent and coherent manner so that every common man could easily comprehend the main objective.
5 NEXT STEPS

The very steps that should be taken by all the concerned governmental and non-governmental organizations in this need of hour are:

- Since the maintenance and regulation activities of filtration plants are not done adequately by the concerned authorities (CDA), so they should pace their efforts and take effective measures to improve their performance as well as functionality of the filter units.
- Proper maintenance of plants, ensuring cleanliness, and replacement of water filters and other necessary gadgets should be done regularly.
- To ensure that water is potable, its monitoring through chemical and microbiological analysis should be carried out regularly from its source to tap all over the plant.
- Public should be made aware of their personal responsibilities by arranging awareness sessions for them and by improving the communication forums between the people and the authorities.
- Some of filter plants have broken taps, some are being destructed by the recent construction activities and some are being closed due to nonfunctional filters. So, CDA should formulate a plan of installing more filtration plants to fulfill the rising water needs of the entire population of Islamabad.
- Active organizations like IUCN, SDPI should help and give effective suggestions to CDA on how this institution can improve its performance, management and communication skills and how to develop more effective water supply schemes in Islamabad.
- Operators and staff awareness and their commitment to serve to excellence should be given most important by the concerned authorities (CDA).
- Most importantly, we should change our behavior and thinking about water, the way we use it, the way we waste it and the way we dispose of wastes in our water.