ENVIRONMENTAL MANAGEMENT FOR MENACE OF WATERLOGGING OF CHASHMA JHELUM LINK CANAL IN THAL DESERT AREA – A CASE STUDY

By

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ABSTRACT

This Paper deals with the malady of seepage from Chashma-Jhelum Link Canal from RD-160 to RD-240. The link canal is an unlined earthen canal with designed capacity of 21700 cusec which is liable to raise upto 26000 cusecs after the commissioning of Greater Thal Canal. The water supply link canal infill can develop such problems in desert areas. The study consisted of areas submerged by seepage water, extent of the severity of problem, the effect of canal water on ecology, land contours, endangered water regimes and profiles. The ultimate effect of waterlogging on human activities is the subject of this Paper. The area of study includes Adhikot, Chann, Rangpur and Chak 19, 20 & 29 M.Bs. The presently total affected places in these villages come to about approximately 18061 acres.

In addition to agricultural land a large number of human habitats and infrastructure i.e. roads, schools and hospitals are also damaged. The reclamation measures are suggested for the rehabilitation of this land. WAPDA Environmental Cell (WEC) has worked on environmental aspects of this menace of seepage water. The measures were suggested including various anti-waterlogging alternatives to improve the degraded conditions damaging lands, crops and infrastructure for agro-socio-economic uplift of the affected communities. In conclusion, the negative affects of severe waterlogging needs attention and government is taking remedial measures to obviate it.

1. INTRODUCTION

In early history, man discovered that he could draw an immense benefit from providing the plants with a regular water supply and the first irrigated farming in Jericho dates back to 7000 B.C. This scenario of irrigation enhanced to such an extent that in year 1800 the total irrigated area was approximately 8 mha, in 1950 it was 100 mha and by 2000 it was 255 mha. Even in subcontinent the history of irrigation is very old. But revolution had taken place during British Raj while, Indus Basin was extensively used for irrigation purposes. There arose a conflict between India and Pakistan regarding the use of water since independence. As a result of the settlement of water conflict, eight link canals were constructed to supplement water shortages in eastern parts of Pakistan as eastern rivers flows (Ravi, Beas and Sutlej) were handed over to India and Pakistan has to live with western rivers (Indus, Jhelum and Chenab). Pakistan has an irrigated area of 42 million acres. Its irrigation systems comprise of Indus and its major tributaries having three major reservoirs (Tarbela, Mangla and Chashma), 19 barrages and headworks, 48 main canals, 12 link canals with a total capacity of 1,30,000 cusecs.

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The extensive irrigation supply network has created the problem of waterlogging and salinity mainly because of inadequate drainage facilities and seepage from irrigation canals. The link canals were constructed to divert the nearly 24 million acre feet of water annually. However, these canals further aggravated the twin menace of waterlogging and salinity by adding nearly 3 MAF of water annually to the groundwater reservoir. This Paper is about the seepage around Chashma-Jhelum Link Canal. The Chashma-Jhelum has a total length of 64 miles from Indus to Jhelum, with present design discharge of 21,700 cusecs and bed width of 380 feet alongwith full supply water level of 14 feet. Lower part of 43 miles of CJ Link Canal traverses the Thal desert (Figure-1).

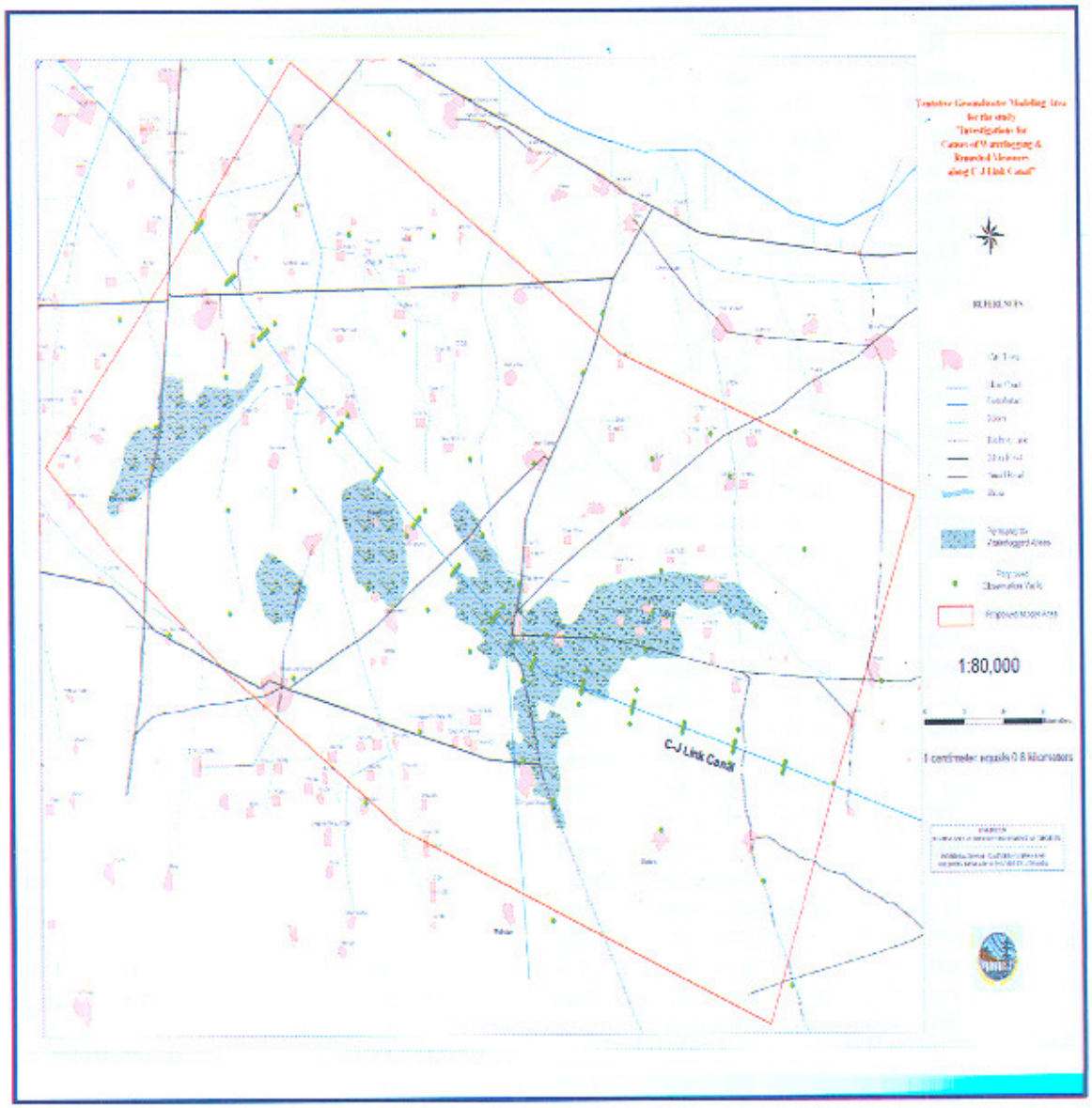


Figure-1 – Chashma Jhelum Link Project Area

The Link Canal passes through the sandy area of semi-arid climate from RD-160 to RD-215 which is in filling. The waterlogging menace was predicted even before commissioning of the canal. A drainage report of this area with the help of 300 tubewells was submitted by WAPDA in 1971.

The seepage of undesirable water affected approx. 18061 acres of cultivable land. Some halfhearted strives were undertaken but they did not pay dividends. 40 tubewells in Chann and Adhikot area alongwith 5 pumping stations and 21 lift pumps alongwith high level channels i.e. bricklined upto 3 kms length had mitigatory effects only in initial years. These pumping stations and water channels are in miserable condition and this plight becomes further gloomy when you encounter only few out of 40 tubewells functioning off and on. The area gets flooded only when water discharges are higher. But when discharges are below 10,000 cusecs the conditions are mitigated by backflow into the canal because of water level difference. The canal seepage has further gained momentum with the passage of time. Pumping stations and tubewells has steepened the hydraulic gradient and increased the seepage rate. But by discarding existing system, we further enhanced it, high flows in the canal for a long duration are also adding to present scenario.

Any one of the aforementioned remedial measures can improve the situation but uprooting of people and their settlement at other places is not environment friendly act. The unwanted seepage in affected area is not only resulting in wastage of water but also colossally disturbing socioeconomic status of inhabitants there. Such type of undesirable water loss in any part of the world is to be remedied to improve the supply systems and ensure better availability of water.

2. SEEPAGE PROBLEM

Seepage from main irrigation canals may have a sizable part of the overall water losses especially where the canals are unlined and in areas where soil percolation rates are high (White, 1978). Loss of water due to seepage may be as high as 36% in the alluvial plain of Pakistan (ICID, 1967). While in Australia losses of 9-18 mm for irrigation water per day are common in sandy subsoil areas (Carruthers & Clarke, 1981) in USSR the losses from Karakoram Canal were more than 43% of the overall discharge at the head (Holy, 1976). In Grand Valley USA there is 23% of salt water leaking from canals and ditches, 32% from the lateral canals and 43% from on-farm seepage (Hayatt et al 1976). The severe condition can be imagined from photographs (Figures 2-7).

Paper exclusively deals with the seepage water from CJ Link Canal in adjoining area and its magnitude, it effect on ecology and human settlements. Various ways can be adopted to curb this undesirable menace from RD-160 to RD-240 (Canal miles). The villages affected have lost their 18,061 acres agricultural land while after the operation of G.T.C. the area from RD-160 to RD-180 will be more severely affected. Presently the water level fluctuation in canal directly affects the submerged adjoining areas. The average flow patterns for previous three years reveals that during 2005 an average monthly 11125 cusecs water was discharges within 228 days, while in 2006 an average monthly discharge was 9425 cusecs within 320 days, while in 2007 average monthly (daily average discharge calculated on monthly basis) was 13429 cusecs within 290

days. Peak months of discharges remained in August, September, November and December for 2005, for 2006 they were December, January and June. For 2007 April, May, September and November. These trends clearly show that water discharges were not according to any set plan but as per demand in lower reaches. This supply on demand is also waterlogging the adjoining areas without any set patterns. This waterlogging remained severe in 2007 as compared to other two years. The waterlogged areas drastically reduced to bare minimum in 2006 as discharges in canal remained below 10,000 cusecs for major portion of the year.

Fluctuation in water level in canal also effects the villages on both sides i.e. the submerged areas at peak seepage is 18,061 acres while it gradually emerges with the reduction in water level in canal. Until, at 10,000 cusecs level water starts to flow back into canal and below this level the affected area reduces to bare minimum, if water discharges remains at lower side for fairly long time. It was observed so in 2006. The option of lining the canal can stop the seepage from canal but effect already caused on aquifer and surface water with leaching of salt into it cannot be eradicated only with lining of canal, the pumping of lentic water from both adjoining areas of canal will be required to be drained back to canal. So, lining of canal and rehabilitation of present choked system will serve the purpose. The place cannot be utilized for recreational purposes due to shallow water regimes and unpredictable fluctuation in water level.

The submerged areas in Rangpur Baghore can be utilized for fish culture to some extent. Out of more than 5000 acres submerged land of this village, water always remain standing in approx 3000 acres. Whatever the water level is in the canal, this area can be exploited through proper aquaculture techniques. During a recent visit the fishing activity in this area was observed. With latest aquaculture practices fish can be cultivated here. Various species including benthic, column and surface feeders i.e. Oreochromis mossambicus, Catla catla Cirrhina mrigala, Cyprinus carpio, Hypophthalmychthus molitrix, Arichthys nobilis and Labeo rohita needs to be considered for culture. To exploit water vegetation Ctenophyrangdon idella is the real tool.

To try other options in Adhikot and Chann will be useless. The drainage of surface water with EC (dsm^{-1}) more than 3.00 and SAR more than 9.00 is the feasible option and lining of canal is the dependable remedy. Other measures including the conventional method of reducing seepage are often of chemical nature. These include Colmation, used for sandy porous soils. In this process the system is flushed with water containing small soil particles in suspension. These seal the interstitial soil spaces, reducing the porosity of soil. Alkalinisation, a chemical lining technique involves the adding of sodium salts to the soil. These soil wells once saturated by exchangeable sodium reduce the porosity of soil (Michael, 1978). These are costly measures along with lining of canals with plastic sheeting or concrete. The better and judicious supply of water through link canal in semi-arid area can be safely taken care of without seepage only if the canals are lined before their commissioning. In future this prospect may be considered for proper integrated water management.

3. THE RESULTS AND DISCUSSION

With the commencing of Indus Water Treaty 1960, the water rights of three eastern Rivers of Indus Basin were exclusively granted to India. To cope with the emergent water deficiency, a systematic water storage and supply program was chalked out. Besides, many other measures, 8 No. link canals were also constructed. The Chashma-Jhelum Link Canal is also one of these which was constructed during 1968-71 under Indus Basin Treaty. It offshoots from River Indus at Chashma Barrage, ultimately falls in Jhelum River near Shergarh. The Canal is an unlined channel with a designed capacity of 21,700 cusecs. Greater Thal Canal is being constructed and it off-takes at 180 RD of Chashma Jhelum Link Canal. In near future, with the operation of Greater Thal Canal the discharge capacity of Canal upto RD-180 is expected to enhance to 26000 cusecs. The Canal from RD-0 to RD-160 is in cut and at full supply level is below the natural ground elevation. The same is the case from RD-240 onwards. While the area from RD-180 to RD-240 (and is in natural depression) and at full supply level is higher than the surrounding natural surface. The adjacent area is a semi-arid zone.

The afore-stated reach was severely affected by water-logging. The annual net seepage from CJ Link Canal is equal to 180564 AF and 75% of it is recharge to aquifer (IWASRI Report 2008). This unlined link canal acted as a vital line source of recharge to the groundwater reservoir also. The area presently being submerged at maximum discharge of canal i.e. full canal level is 18061 acres. The most affected village is Rangpur Bhagore with the affected area of 5600 acres and then Adhikot at RD-180 (The spot from where the Greater Thal Canal also off-takes) with an affected area of 2700 acres. The extent of severity of problem was gauged through visual surveys. The Rangpur Baghore is more severely affected than any other place being lowest lying area in the vicinity. The rise in the seepage in the affected area is because of groundwater wedge had been created.

The ecology of the affected area has drastically changed sinceoperation of the canal in 1971. The semi-arid undulating land in vicinity was under extensive barani cultivation. A fairly devastating effect is encountered in agriculture and ecology. The total area affected changes according to the water level fluctuation in the canal. A considerable number of human settlements and infrastructures received a severe blow. Various reclamation measures were suggested throughout the currency of period i.e. 1971 to 2008. A lukewarm strive in the shape of couple of dozen tubewells and subsurface and higher-elevation channels along with five lift pumps have never performed the miracles expected from those.

The ways suggested earlier include rehabilitation / remodeling of existing drainage system, construction and provision of new seepage drains with pump station, construction of gravity outfall drains to River Jhelum and last but not the least is brick lined/concrete lining from RD-160 to RD-240. All the options were taken care of; least costly is rehabilitation of existing tubewells and seepage drains with an estimated cost of 37 million. Afore-stated final waterlogging controlling measure can check the further spread of marshes / wetlands but will not lower the watertable considerably in low lying areas i.e. (where contours show 615 spd level i.e. Adhikot and Chann while 610 spd at Rangpur Baghore will remain marshy).

In case of lining there will be a total change in water regimes i.e. the seepage will be drastically reduced. However, improvement in underground water quality is questionable. Presently the specimen taken from wells, tubewells and marshy places show a high percentage of salinity which is harmful for any sustained activity of agriculture. In case of other measures the severity of the problem will be reduced but total eradication is not on the cards. The presence of this menace will further aggravate the problems of water logging in future. The fluctuation of water level in adjoining areas with the fluctuation in water level in canal renders this land further vulnerable for any recreational activity. Only the marshy areas of Rangpur Baghore can be used for aquaculture to some extent.

Water is lifeline for Pakistan and every drop saved is as if we are fulfilling our duty. The water storage capacity, its retention and problems in supply system are already in precarious position. To take care of undesirable seepage from link canals can make us enable to avoid loss to national economy. Such undesirable loss of water causing waterlogging is posing a threat to positive, viable, judicious, sustainable and effective use of canal water for agriculture. Down to earth environmental friendly measures are required to be undertaken to safeguard against the water utility problems.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The environmental assessment of the CJ Link Canal conducted in the light of proposed interventions and prevailing laws of the land does not indicate any significant negative impact of such nature or magnitude that would suggest any of the options to be infeasible.

It is an established fact that in case of adoption of any of the remedial measures to be undertaken, the potential environmental and social impacts identified should be taken care of by adopting proper strategies. Thus the significant impact includes i.e. physical, biological and socio-economic impacts with the provision of the improved drainage facilities to the affected area, the agriculture production will enhance, the drainage of derelict water from a vast fertile land will relatively improve the soil productivity, decrease the watertable depth and soil salinity/sodicity in the affected area.

The restoration of agricultural activities will bring general prosperity which will ultimately boost the socio-economic condition of beneficiaries.

4.2 Recommendations

In case of utilization of these derelict seepage waters for the aquaculture and agro-forestry all pros and cons should be considered vis-à-vis water level fluctuation, unpredictable drainage conditions, water quality, provision of suitable ichthyofaunic species according to prevailing water regimes, provision of technical know-how to the affectees i.e. about latest aquaculture and agro-forestry practices etc.

In case of adoption of option of improvement of drainage facilities, the person who will be affected due to establishment of new drainage improvement infrastructures should be compensated properly as recommended in Environmental Assessment Report of the project.



Figure-2 : CJ Link in Flowing Condition



Figure-3 : A Pumping Station along an open drain



Figure-4 : A chocked/poorly maintained open drain in CJ Link Area



Figure-5 : Waterlogging in CJ Link Command area



Figure-6 : A poorly maintained open drain



Figure-7 : A sump and pumping station and effluent drain

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IMPACT OF WESTERN ECONOMIC POLICIES ON THE PLANET [WITH SPECIAL REFERENCE TO PAKISTAN]

By

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Pakistan has been at the forefront of many policies that have been developed and tested in the developing countries. It is as if we were the experimental guinea pigs available to the world forum for whatever they needed to test. The effort would be to show the connection between what has happened and what is likely to happen if we continue down this lane and to see whether there is a way out for the future.

The sectors that are going to be set up for consideration and to see the impact of these on the planet and to take examples from Pakistan to see the causes and the effects of these policies. Take agriculture and see what has been the effect on the lands and the water of the country. Pakistan was self sufficient in food and its food security was secure given that regions had their own system of production and in fact the villages were self sufficient in not only food but also nutrition security. There were no cases of malnutrition as such. Now over 70% of children under the age of 5 are suffering from malnutrition. How then has all this happened?

Let us first look at the green revolution. The green revolution promised much and provided less and what it did provide was in the long run absolutely toxic to the soils. Pakistan has been using the technologies so perpetrated for now over 68years. Things do not happen in simple straightforward manner. The green revolution required many things to go with the seed that was provided by the international seed centers [CGIAR-Consolidated Group on International Agricultural Research]. The fetish was that the seeds were responsive to inorganic fertilizer and therefore high yielding. The seeds were belonging to one particular seed family. These seeds [veeri varieties as they were called] had a very narrow genetic base. The loss of bio diversity is now hitting the nations around the world. The viral attacks that have struck the wheat varieties are now not being addressed. In fact they were never addressed and only there identification is now possible. What good is a debilitating disease that can only be identified but cannot be cured? These viral problems are used to put the fear of God in the policy makers mind. Go through the list and when these started and you will come across stem rust, karnal bunt, yellow rust and now UG99. The idea is to keep the third world non-focused. It happened with Y2K at the start of the millennium and the hype that was created was no one's business. President Leghari held meetings and wasted every one's time and the essence of the watch was what if this was correct and the entire computer system collapsed. Well what if it collapsed? So the third world must be kept on the run all the time and how dare they establish any degree of independence.

There were other problems with the green revolution. These were in the realm of soils and the water holding capacity of the soils. The negative charge on the inorganic nitrogen fertilizer did not adhere to the negative charge in the soil with the result there was nitrification of the soils and Nitrogen also being volatile was lost to the atmosphere.

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There was some apprehension that the full use of nitrogen was not being s\done and my own assessment was that it was only 27% but now new evidence has shown that it is as low as 5%. The MNCs responsible for these are now suggesting that the use of N should be made flexible meaning thereby that it should be used at a later stage and in minimal dosages. Funny that this should come at least 68 years later. The N that goes to the subsoil creates issues for the subsoil water and we know that once that water goes to N we have no other options then to give drinking that or else have a spinal cord of sixty year old when the age is only twenty. The effect of prolonged use of Phosphates is that it develops arsenic in water. So there is double jeopardy as the subsoil water can have Arsenic laced with N.

What of the soil? The soil has become a sieve and it does not hold any water. That means that if the green revolution is to be green then more water is to be used. Water is in the amount that it is and it can never be guaranteed to be on the increase especially where irrigation is based on the run of the river system. The loss of the productive base continues unabated when the farmers are asked to increase the input by 10% given the production base that has to be maintained.

More use of fertilizers means that there has to be more water. More water means the construction of a dam to supply water. That means that there has to be fertilizer purchase from near MNCs monopolies. That means the loans have to be for the development of the dams [enormous] and that means that fertilizer purchase would have to be from the west and that means more loans from the west and western-based donors. The chain effect continues by simply when more concrete work has to be done the cement factories must come up and that means that more loans from the IMF and with their stated conditionality[s] that would not only create a hiccup in the macro economic framework but also create an issue on the foreign exchange and the inflationary aspect that would mean the devaluation of the money supply.

So what kind of systems have they got to control the third world and keep them in their place. They are unmindful of what happens to the planet. I know and you know that the selfishness of the system is proverbial and that they will do something and end up doing something quite different.

Consider the planet and the changes that are required to put in to place. We have been told that the planet is in a time warp and that it could explode anytime. Fine. It can explode. The explosion is possible as a result of the war in Iraq and because of the Afghanistan war at the moment. The use of smart bombs has created such a problem in the environment that the entire glacier system has been affected. Man made problems have created such an issue that the kargill war in Siachin has left the glaciers under stress and the continued use of fossil fuel as accelerated the glacier melt. This glacier melt will have consequences for Tarbella dam that is filled by the glacier melt. So what if that is dead to Pakistan? Do you have any option to the vital requirements of agriculture?

I can go on at the meanness of the humans in dealing with the environment.

The west is prone to tell us all about the methane gas that we have been generating from the rice fields and the livestock sector that has been the lifeblood of the small farmers. What and who is responsible for this? Just look at the legacy of the colonial

system and they have been doing everything that is against the human systems and hence against the natural system. The agrarian system spells out doom of another kind for Pakistan. The education system that is in the rural areas speaks volumes of the way the sub-continent has been devastated in the past and the worth of this area reduced by the policies that prevailed then.

Come to Industry and we see the same sport of pollution that was visible then and the cities that have suffered the consequences of the industrial policies encouraged by the World Bank to meet the demand structure and the job requirements of the west. The group of eight or seven meets regularly and determines the course of action and deliberations that would be forced on the developing world. The consequences of these policies are visible in the environment and the pollution that has been caused in the Gujranwala, Sialkot, Faisalabad and Site area in various parts of the country.

Similarly the urbanization is a factor that the WB has encouraged so that the third world becomes increasingly in the consumer society. As a result we have destroyed the harmony of the third world and the individual countries. Urbanization is responsible for the consumer market where the west comes to sell its goods and where the machinery and the wherewithal that is required for its production. The urbanization has also eaten in to agricultural land and as much as 3 million hectare of land has been eaten by the housing sector. All this has led to the build up of the car fossil fuel usage. The cars and transport that are being built for the countries and the auto industry will and will continue to burn fossil fuel that will change the weather conditions of this country and this planet.

CDA needs to be singled out as a single most disaster organization dealing with the urban problem. The problem is compounded when the top boss is insensitive to the requirements of the general public and not the requirements of the elites. The one most basic issue that is coming up in the CDA is should we in Pakistan be responsible for the copycat formula of the developed countries. Should we buy expensive machinery that is earth moving and that has upset the entire applecart? CDA has to understand that what is mountainous does not have to be leveled. The amount of small hills and mountains that it has decimated is any one's guess. It might not be wrong to say that the plains survive because of the mountains. Just imagine if Pakistan was all plains? The levelers of land do not realize the ultimate problem that might arise. The fact is that when greed comes in to play there is very little that any one can do. The solution may well lie elsewhere.

The plethora of human activity is such that there has been massive perpetuation of activities that have cut across environment decency. This has to be rectified. The rectification can only come through if there is basic understanding of human and nature interaction. Humans are pretty poor at that. So how does that harmonize with the policies that have to be put in place? There is no point in being early on the scene and becoming a preacher when in the past the nations were poachers. The situation that a preacher becomes a poacher is by itself despicable.

To be in harmony with nature is to understand the nature of things. During the EQ in Pakistan I was a witness to the fact that not a single natural asset was disturbed or destroyed. Man made buildings created havoc amongst the population. Engineers that had devised those buildings went Scot-free. In Berlin those companies that built the

capital buildings are also free despite the fact that a considerable loss has accrued to the German government. All this smacks of the danger that is there due to humans and the belief that nature can be harnessed. Humans are arrogant and do not realize the potential that has been lost. Is there something wrong in the way that we lived earlier on and the manner of our satisfaction?

So before we go in to globalization and a further general call let us see all that is being proposed in a manner that is objectively like the green peace movement but more up scaled. Since there is no limit to what can be done how about the elite deciding that the man made electricity dependent gadgetry system is faulty and needs urgent correction so that the many pitfalls created by the elites is corrected.

Try something different, as man-made laws are ultimately immoral, as they do not cater for the needs of man but for the greed of the few. There is a requirement for the just to come in to play.

There is much to say and much more to do. The journey is just begun and there are many mountains to climb and many rivers to cross.

DRINKING WATER QUALITY BETWEEN SOURCE AND POINT-OF-USE IN SATELLITE TOWN, RAWALPINDI – A CASE STUDY

By

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Abstract

A detailed survey of the drinking water distribution system in Satellite town, Rawalpindi was performed. The aim was to investigate whether the distribution system was capable of maintaining high water quality from the water treatment facilities to the consumer end. The collected water samples were analyzed chemically and microbially and results showed that the distribution system can maintain high water quality with residual chlorine at all sampling stations. The value of free residual chlorine ranged from 0.69 to 0.27 mg/l, whereas maximum total organic carbon (TOC) content obtained was 3.6 mg/l, similarly turbidity varied from 2.82 to 4.1 NTU. Temperature observed at the time of collection of water samples ranged from 16.9 to 17.6 °C, total dissolved solids (TDS) values varied from 141.1 to 223 mg/l while conductivity values fluctuated from 286.3 to 427 µS/cm and pH ranged from 7.22 to 7.65. However, there was no evidence of feacal contamination at any of the selected stations.

Keywords : Drinking water, distribution system, MPN, *E. coli*, TOC, Residual chlorine

Introduction

Water distribution systems are vulnerable to microbial contamination. Pathogens can enter the distribution system through cracks and joints in pipes. The use of chlorine for the destruction of microbial pathogens is essential to protect the public from outbreaks of water borne diseases. Chlorine as well as other disinfectants produces a variety of chemical byproducts. The risk from the presence of microbial pathogens in drinking water is estimated to be several orders of magnitude greater than the risk from chlorination by-products. Chlorine remaining in the water supply, or added after disinfection, is available to fight against potential contamination in water distribution and storage systems that might enter through leaks and pipe breakages. Residual chlorine concentrations of approximately 0.2-0.3 mg/L are often maintained in distribution systems to serve as a sentinel for the entry of pollution and to prevent the growth of nuisance bacteria and other organisms. Minimum chlorine residual must be maintained at the furthest distribution point and 0.2 mg/L of chorine residual is advisable (ADS, 2005). In developing countries, the use of chlorine is often the only affordable mean of disinfecting drinking water. Diseases arising from the ingestion of pathogens in contaminated water have the greatest health impact worldwide.

In Pakistan, the vast majority of the country's 135 million inhabitants do not have access to safe drinkable water. According to National statistics, 56 per cent of the total population of Pakistan enjoys safe drinking water and 24 per cent have basic sanitation facilities. For the rural population the figures are 45 per cent and 10 per cent respectively (Raza *et al.*, 1998). Pakistan's unsafe water supply, low sanitation coverage and

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people's poor hygiene habits meant, 60 percent of children suffering from diarrhea (IRIN, 2006). In 2004, the under-five infant mortality rate in Pakistan was 101 per 1,000 live births and the estimated number of annual under-five child deaths was 478,000 (Shehzad, 2006). According to Pakistan National Conservation Strategy (1992) about 40 per cent of communicable diseases like infectious hepatitis, gastroenteritis, diarrhea, typhoid giardiasis, intestinal worms, trachoma and scabies, in Pakistan are water borne and 30 to 40 per cent of the population (served through piped water) is deprived of safety measures.

Beside this, there is no regular monitoring program to assess the water quality of the surface and groundwater bodies at the treatment plants or in the distribution system except at few major water treatment plants in the country (Farooq *et al.*, 2008). Little research work has been compiled, regarding the bacteriological quality of drinking water. Most of the reported studies in Pakistan only indicate contamination by fecal source through detecting the presence of fecal coliform in drinking water without any information on the level of presence of chlorine in water distribution network. Essentially all disease outbreaks have been traced to cross connections in spite of the fact that water leaving the plant was deemed to be safe (Malick *et al.*, 1998).

In a report of Pakistan Council of Research in Water Resources (PCRWR), Islamabad and provincial metropolitans are being supplied highly contaminated water for drinking, risking lives of the citizens and which badly damages natural system of human body making it prone to a number of serious diseases. It was further reported that drinking water needs chlorine process at a specific ratio for killing bacteria, before supply but the concerned departments either do not bother for chlorine process and if in a few cases it's processed then a specified dosage of chlorine is ignored (Siddique, 2007).

The ground and surface water sources are not regularly chlorinated. The staff at the water sources is not trained and skilled to run the sources amicably. In the distribution system many leaking spots are seen where water gushes out of pipes to form a breeding ground for mosquitoes and other pathogenic bacteria and goes unheeded for months. When the intermittent supply ends the same leaking spots become suction points and suck all the contamination into the pipe line. Poor Budget allocation, sloppy governance and ageing infrastructure are some of the other reasons. There is no uniform application of PSQCA (Pakistan Standards and Quality Control Authority) standards in the country. There are PSQCA standards (PS-1932-2002) for piped water and PSQCA standards (PS-4639-2002) for bottled water. The PSQCA standards for piped water are voluntary whereas the PSQCA standards for bottled water are mandatory in nature, while the need is that the standards for both kinds of water should be mandatory (Tariq, 2005). Hence, National drinking water policy is the need of the hour. The policy should ensure that local bodies' representatives are responsible for providing safe drinking water to the consumers. It should also ensure that minimal mandatory standards are applied to both bottled and piped water.

Material and Methods

To assess the current state of surface water quality in Rawalpindi, water samples from Satellite Town were collected for analysis. Water supply in Rawalpindi is under the

jurisdiction of Water and Sanitation Agency (WASA). Water after treatment from Rawal Lake treatment plant is stored at Siddique Chowk Underground tank and than supplied to the local residents. Water samples were collected from treatment plant, underground storage reservoir and than consumer houses were selected receiving water from WASA water supply. The collected samples were analyzed for chlorine residual, (MPN: total coliform and fecal coliform), spread plate count and TOC as per Standard Methods. Sampling sites with their distance from treatment plant is shown in the Table 1 below:

Table-1: Sampling stations along with sampling distances

Station numbers	Station name	Distance from zero point (kms)
1	(Pindi Satellite town-Treatment plant) PS-TP	0
2	(Pindi Satellite town-Undergound tank) PS-UGT	10
3	(Pindi Satellite town- House no. 1) PS-H1	0.2
4	(Pindi Satellite town- House no. 2) PS-H2	0.25
5	(Pindi Satellite town- House no. 3) PS-H3	0.1
6	(Pindi Satellite town- House no. 4) PS-H4	0.30
7	(Pindi Satellite town- House no. 5) PS-H5	0.15
8	(Pindi Satellite town- House no. 6) PS-H6	0.2

Chemical analysis

On site, samples were analyzed for temperature and pH (Hach pH meter sension 1), turbidity (Hach 2100) and TDS and electrical conductivity by Hach meter (sension 5). Chemical analysis for chlorine residual, free chlorine, monochloramine, dichloramines and total chlorine was carried out using DPD Ferrous Titrimetric method. TOC was analyzed by TOC analyzer multi win N/C 30 as per Standard method (APHA, 2005 & Collins and Lyne, 1985).

Microbiological analysis

The total coliform and fecal coliform counts were determined by the multiple tube dilution procedure given in Standard Methods for the Examination of Water and Wastewater. Standard plate counts (SPC) were also determined as per Standard Methods (APHA, 2005 & Collins and Lyne, 1985).

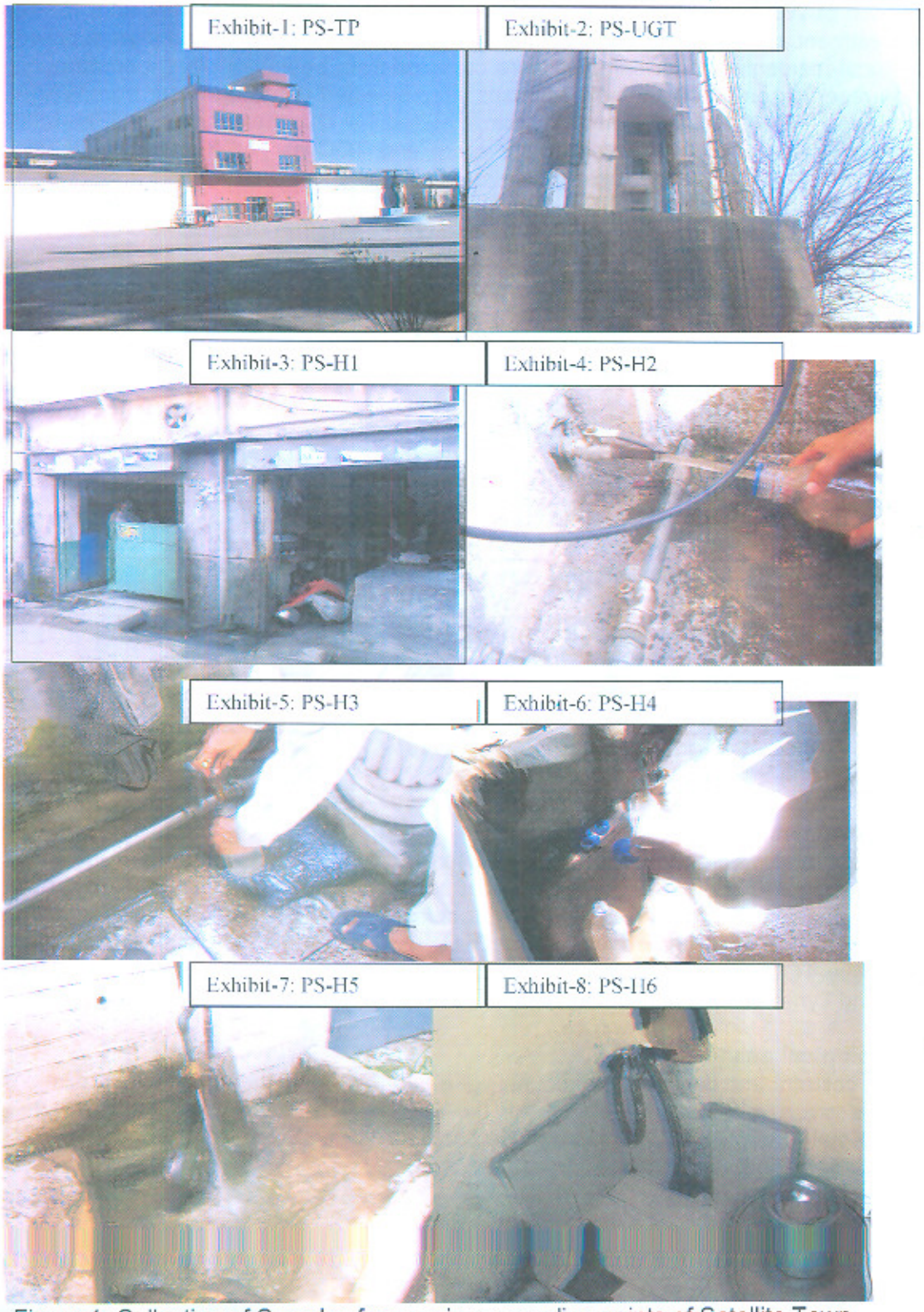


Figure 1: Collection of Samples from various sampling points of Satellite Town

Result and Discussion

The detail of the analysis results of drinking water samples collected from the distribution lines of Satellite town are graphically represented from Figure 2 to 6. Water samples collected from Rawal lake water treatment plant showed satisfactory results with values of all parameters within WHO standards as mentioned in Table 2. The value of pH was 7.38, TDS was 218 mg/l, conductivity was 434 µS/cm and free chlorine residual was about 0.69 mg/l. Microbiological quality of water was satisfactory with no evidence of *E. coli*.

The destruction of microbial pathogens almost invariably involves the use of reactive chemical agents such as free chlorine, chloramines, chlorine dioxide and ozone. Free chlorine is an effective disinfectant for bacteria and viruses, and compares well with the efficiency of ozone and chlorine dioxide for these microorganisms. The World Health Organization recommends maintenance of a disinfectant residual of 0.2 to 0.5mg/l in a distribution system under normal operating conditions (WHO, 1997). The collected water samples from satellite town were analyzed for total chlorine, free chlorine residual, monochloramine and dichloramines concentrations. Results indicated that the value of total chlorine ranged between 0.80 mg/l at *PS-UGT* to 1.69 mg/l at *PS-H1*. Lowest value of free chlorine was available at *PS-H3* with values ranging from 0.09 to 0.25 mg/l with an average value of 0.15 to 0.69 mg/l at *PS-TP* respectively (Figure 2). Mean value of residual chlorine obtained at each station is plotted with ± standard deviation (SD) value. From the figure it is clear that most of the stations were meeting the standards of residual chlorine concentration. Among disinfection techniques, chlorination is unique in that a pre-determined chlorine concentration may be designed to remain in treated water as a measure of protection against harmful microbes encountered after leaving the treatment facility. Monochloramines were found highest at *PS-UGT* i.e. 0.18 mg/l and lowest at *PS-H4* i.e. 0.07 mg/l whereas dichloramines varied from 0.03 to 0.13 mg/l at *PS-H5* and *PS-UGT* respectively .These results are inline with the study conducted by Agard *et al.* (2002) and Geldreich, 1996.

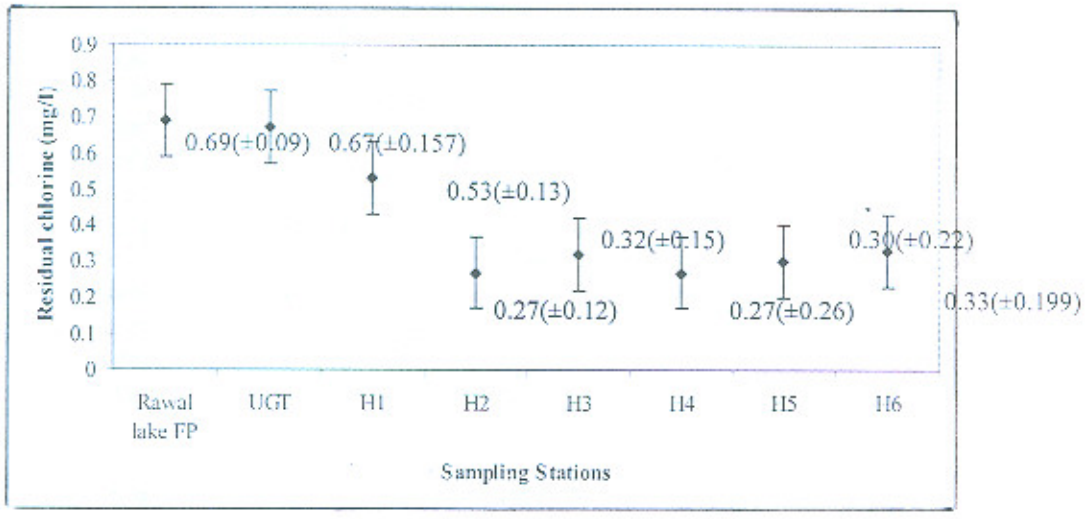


Figure 2: Average value of residual chlorine obtained at different sampling stations of Satellite town.

Table 2: WHO limits of drinking water quality standard

Sr. No	Water Quality Parameter	Physical Parameter	WHO Limits
1.	Appearance	Optical observation	Unobjectionable
2.	Odor	By Smelling	Unobjectionable
3.	Color	Optical observation	Unobjectionable
4.	Taste	Organoleptical	Unobjectionable
5.	Temperature	^{0}C	12 ^{0}C
6.	Turbidity	NTU	5 NTU
7.	pH		6.5-8.5
8.	Electrical Conductivity	µS/cm	2000 µS/cm
9.	Total Dissolved solids	mg/L	1000 mg/L
10.	Residual Chlorine	mg/L	0.2-0.5 mg/L
Biological Parameter			
11.	Total Coliform count	CFU/100ml	1CFU/100ml
12.	Fecal Coliform count	CFU/100ml	0 CFU/ml

WHO. (1993). Guidelines *for drinking water quality*

The TOC analysis revealed that the value of TOC was lowest at Filtration plant and underground tank i.e. 0 mg/l. While high values were observed at *PS-H2* and *PS-H6* with values of 2.41 and 3.61 mg/l respectively. At rest of the stations TOC was below 2 mg/l (US-EPA limit)) ranging from 0.75 to 1.44 mg/l. Average values of TOC with ± SD values is shown in Figure 3. These results are inline with the study conducted by Westphal *et al.* (2007) and Chapelle *et al.* (2008). TOC in source waters comes from decaying natural organic matter (NOM) especially humic acid, fulvic acid, amines, urea and from synthetic sources like detergents, pesticides, fertilizers, herbicides, industrial chemicals, and chlorinated organics. Beside this domestic and industrial wastewaters also contribute organic contaminants in various amounts. The recently issued *Disinfectants and Disinfection By-Products Rule* by the US Environmental Protection Agency specifies maximum total organic carbon levels of 2 mg/L in treated water and 4 mg/L in source water to ensure acceptable levels of disinfection byproducts. TOC value of drinking water supply with chlorination is 4 mg/L (EPD, 2001). A study with drinking water supplies has shown that the probability of exceeding the trihalomethane concentration of 100 micrograms/L following chlorination, is minimal for the finished drinking water containing total organic carbon level of less than or equal to 2 mg/L (Wallace *et al.* 2002).

In a study by LeChevallier *et al* (1991), it was shown that the occurrence of coliform bacteria in the distribution system could be associated with rainfall, water temperatures

greater than 15°C and total organic carbon levels greater than 2.4 mg/liter. A high organic content means an increase in the growth of microorganisms, which contributes to the depletion of oxygen supplies causing anoxia (EPD, 2001). According to a study by

Wallace *et al* (2002), TOC monitoring is required monthly for one source water and one treated water sample. If the TOC levels of the source water average less than 2mg/L^{-1} for two consecutive years, or the treated water average are less than 1mgL^{-1} for 1 year, then a public water system would qualify for reduced monitoring to one pair of samples per quarter.

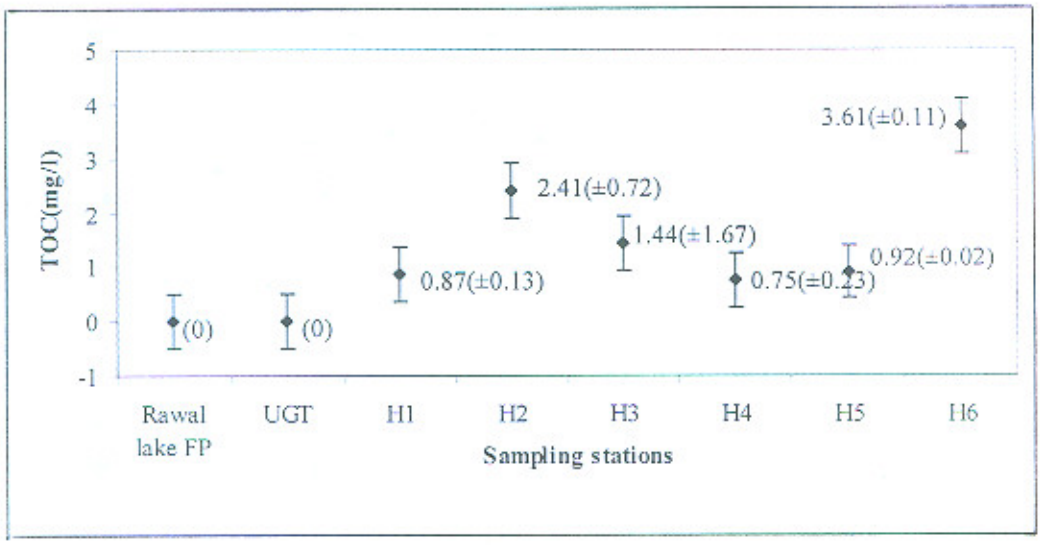


Figure 3: Average value of TOC obtained at different sampling stations of Satellite Town.

From the mean values of turbidity plotted in Figure 4, it is clear that the values were within the Highest Desirable Level (HDL) values of WHO i.e. < 5 NTU ranging from 2.82 to 4.10 NTU at *PS-TP* and *PS-H2* respectively. These results are in accordance with the findings of Egorov *et al.* (2002).Turbidity caused by high levels of organic matter can protect microorganisms from the effects of drinking water disinfection and can stimulate bacterial growth. Waters with high turbidity from organic sources may give rise to a substantial chlorine demand. This could result in reductions in the free chlorine residual in distribution systems as protection against possible recontamination. In Oregon surface waters, chlorine demand had a positive correlation with both turbidity and total organic carbon levels (LeChevallier *et al.*, 1981).The resultant model suggested a 180% increase in chlorine demand for a turbidity increase from 1.0 to 5.0 NTU. Huck *et al.*, (2002) in their investigation of *Cryptosporidium* removal by granular media filtration, noted that an increase in turbidity associated with suboptimal coagulation and breakthrough at the end of filtration runs resulted in deterioration in oocyst reduction, even at turbidity levels less than 0.3 NTU. Therefore, it is critical to successful water treatment and disinfection to keep turbidity levels low.

Temperature observed at the time of collection of water samples ranged from 16.9 to 17.6 °C at *PS-TP* and *PS-H4* respectively which is above WHO limits of 12°C. Temperature is also an important factor which is related to the microbiological characteristics of drinking water through its effect on water treatment processes, especially disinfection, and its effect on the growth and survival of micro-organisms. In

general, disinfection is aided by increased temperature. Working with *E. coli*, Butterfield and co-workers (1943), observed a fivefold increase in the bactericidal effectiveness of chlorine between 2°C to 5°C and 20°C to 25°C. It has also been observed, that when water temperatures rise above 15°C, the growth of colonizing bacteria in the distribution system increases markedly (LeChevallier *et al.*, 1991; LeChevallier *et al.*, 1996; Geldreich, 1996).

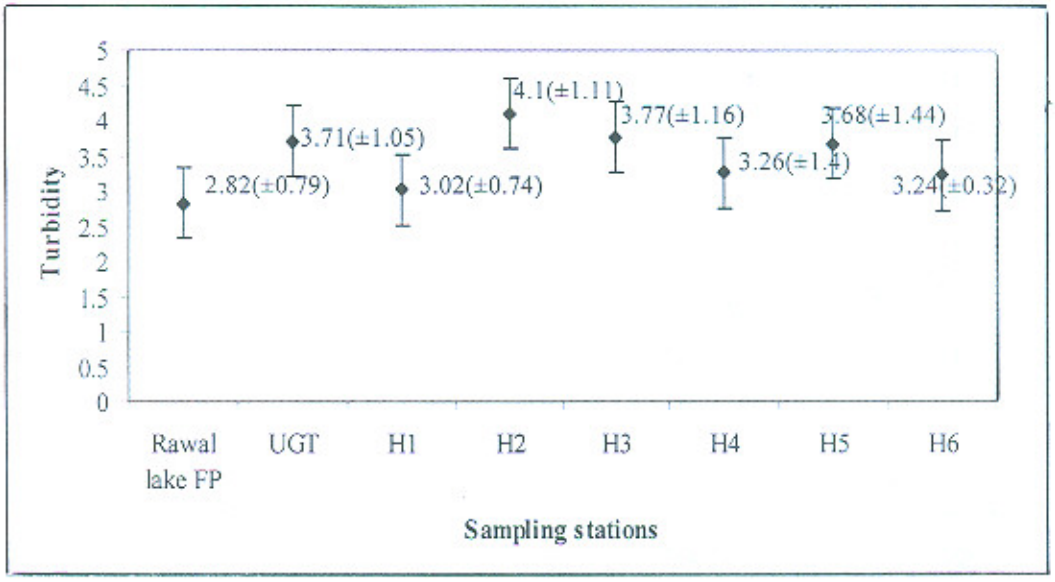


Figure 4: Average values of turbidity obtained at different sampling stations of Satellite Town.

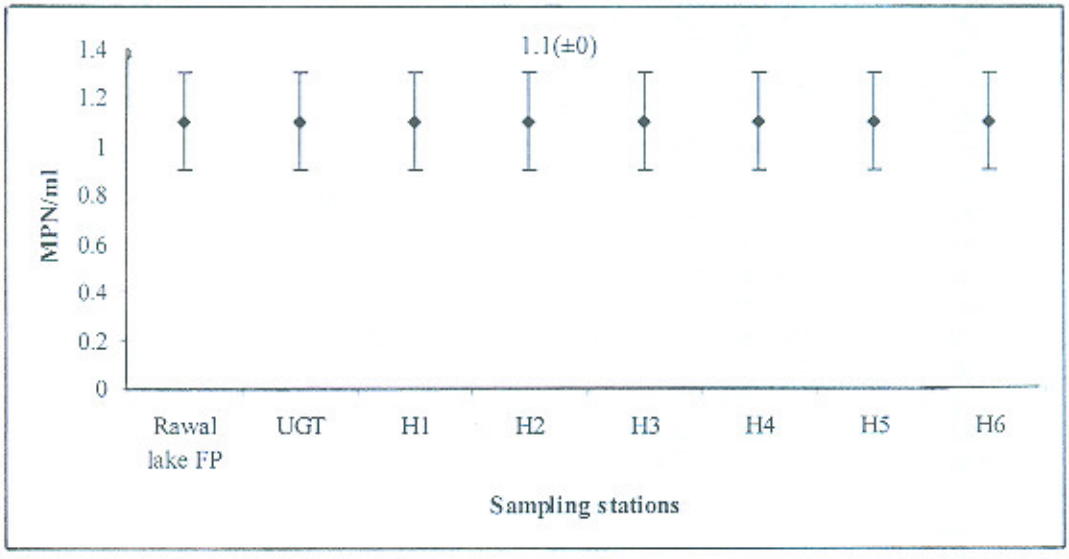


Figure 5: Values of *fecal coliform* counts obtained at different sampling stations of Satellite Town.

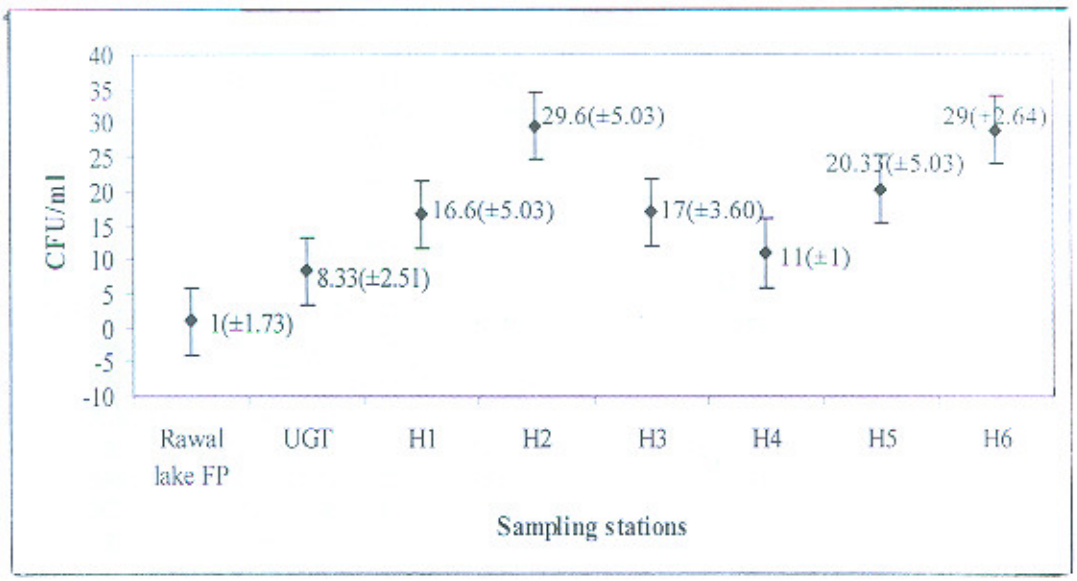


Figure 6: Average value of SPC counts obtained at different sampling stations of Satellite Town.

The lowest value of pH was observed at underground tank with values ranging from 7.14-7.33 with a mean of 7.22. While high pH, was obtained at *PS-H5* with range of 7.55-7.9 and mean of 7.65. All the values are well within the WHO permissible limit of 6.5–8.5. These results are in accordance with the earlier study conducted by Farooq *et al.* (2008) in which the pH values varied from 7.02–7.30. Depending on a number of characteristics of the distribution system, pH can be a strong determining factor in the bacterial and chemical quality of water. Although pH usually has no direct impact on water consumers, it is one of the most important operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8.0. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odour and appearance.
(Langelier, 1946).

Analysis of total dissolved solids (TDS) values of collected samples ranged from 141.1 at *PS-H5* to 223 mg/l at *PS-H3* respectively not exceeding WHO limit of 500 mg/l and conductivity values varying from 286.3 to 427 µS/cm at *Station # 7* and *4*. These results are also in agreement as reported by Farooq *et al.* (2008). With respect to trace metals, water with a very lower TDS concentration may be corrosive and corrosive waters may leak toxic metals such as: copper and lead from the household plumbing and may pose a health risk. While electrical conductivity relates to the salinity of water. It imparts a salty taste to the water (if conductivity > 150 mS/m) while water with conductivity > 300 mS/m

does not slake thirst. Health effects related to EC are minimal at concentration below 300-450mS/m.

Detection of microbial contaminants of fecal origin is a major priority in assessing the quality of drinking water. Water from different sources i.e. river, lakes, reservoirs and groundwater aquifers are subjected to varying degrees of fecal pollution, and consequently freshwater is a vector of transmission of many pathogenic bacteria, viruses and protozoa (Shar *et al.*, 2008). The presence of *E. coli* clearly shows fecal contamination (Ram *et al.*, 2009) and indicates a possible contamination of enteric pathogens (Min & Baeumner, 2002; Bej *et al.*, 1990). The high incidences of waterborne diseases are frequently associated with shiga toxin (STEC) and enterotoxin producing *Escherichia coli* (ETEC) (Ram *et al.*, 2009). The collected water samples were free of *coliform* and *fecal coliform* bacteria. The value of MPN Index/100 ml for *total coliform* and *fecal coliform* was <1.1 and probability ranged from 0-0.3 at all sampling stations as shown in Figure 5. Mean values of SPC count with ± SD values is shown in Figure 6. From the figure it is evident that the values of SPC counts were lowest at water filtration plants with values ranging from 0-3 CFU/ml with an average value of 1 CFU/ml and highest counts were obtained at *PS-H2* and *PS-H6* with an average value of 30 CFU/ml.

Conclusion

Based on the study following conclusions can be drawn:

1) Total 24 water samples were collected from eight different locations of Satellite town, Rawalpindi in order to have a clear picture of drinking water quality.
2) Free residual chlorine was maintained at all the sampling stations with values above 0.2 mg/l, highest residual was obtained at filtration plant *(PS-TP)* and underground tank (*PS-UGT*) with value.
3) High value of TOC content was observed at *PS-H2* and *PS-H6* with values of 2.41 mg/l and 3.61 mg/l respectively which were above USEPA-limit of 2 mg/l in treated drinking water.
4) Water turbidity at all the sampling stations was meeting WHO standard of >5 NTU.
5) The value of MPN Index/100 ml for total coliform and fecal coliform was <1.1 and probability ranged from 0-0.3 at all sampling stations and there was no evidence of *E. coli.*
6) Lowest SPC counts were observed at Filtration plant (*PS-TP*) while highest counts were observed at *PS-H2* and *PS-H6.*
7) Physiochemical water quality parameters such as pH, total dissolved solids and electrical conductivity were found within the permissible limits of WHO standards except temperature which were above the limits.

Acknowledgement

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