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# Public Health Quality of Drinking Water supply in Orangi Town, Karachi, Pakistan

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**ABSTRACT**
*Water scarcity is a serious problem in the mega city Karachi. The problem is more pronounced in the slum areas of the city having poor infrastructure and limited facilities. This study presents a quality assessment of piped water supply in the biggest slum area of Asia; the Orangi town. Forty six samples of piped water were collected from different places and examined for bacteriological and physico-chemical analyses as per methods described in the Standard Methods for the Examination of Water and Wastewater. Environmental health quality of piped water supply is found to be unsuitable for human consumption. Physico-chemical characteristics were well within limits except sulphates as per WHO guidelines and National Standard for Drinking Water Quality, Government of Pakistan (NSDWQ). Chlorine was found only in nine samples which reflect the presence of organisms of public health importance. Most critical were the high levels of total coliforms count (TCC) as total fecal coliform counts (TFC), which were present in a very high numbers as compared to WHO guidelines. The presence of high TCC and TFC count represents poor hygienic and sanitation conditions of the area. The field surveys indicated that water supply system is obsolete that need immediate replacement. The study stresses the need for significant improvements of water supply and sewage infrastructure.*
***Keywords:*** *Piped water, Quality Assessment, Karachi, Orangi Town*

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## INTRODUCTION

Water is considered to be safe if it has no significant health impacts over lifetime consumption [1].However, due to high population, poor developmental infrastructure and financial constraints the problem of water crisis in developing countries is intensified with devastating health risks [2]. Pakistan has no exception. Arnell [3] reported that the people in Pakistan would face severe water stress during the upcoming decades. However, it would be more suitable to state that tangible water strains will depend on how water resources are managed in the future. Briscoe and Qamar [4] indicated that Pakistan has already dropped under the water stress verge and will reach a state of water scarcity by 2035. Approximately 44 % of the population in Pakistan do not have access to safe drinking water whereas 90 % of the population do not have access in rural areas [5]. More than 80% of water deliveries in Pakistan have water quality below the recommended standards for human consumption[2]. Indiscriminate disposal of liquid and solid waste are the leading causes of water pollution[6]. It is estimated that approximately 30% of all ailments and 40% of all mortalities are instigated by bad quality of water in Pakistan[7, 8]. It is assessed that water borne diseases incurred annual national income losses of USD 380–883 million [5].

Karachi is biggest city of Pakistan and the hub of all the industrial and commercial activities. The major source of Water supply in Karachi is through the river Indus popularly known as Greater Karachi Bulk water supply system (GKBWS) those supplies over 70% of city's water. Other sources includes water supply through Hub Dam that accounts for 25%. However, that supply is intermittent dependent on the availability of water in Hub dam. Previously another source of water supply is through Dumlotee wells that contributed 2% in the total water supply to Karachi. These wells are now almost dried due to persistent severe dry spell in the catchment area [9-11]. Due to over whelming increase in the population of Karachi the physical infrastructure available is unable to cope with the growing demands. In Karachi, forty percent of the population is living in slums with limited water supply and poor sanitary infrastructure [12]. Even if the water is available the quality is well below to any national and international standards.

Orangi Town lies in the District West of Karachi and consists of an agglomeration of slum with a total population of over 1.2 million that accounts for more than 10 % of the city population. It is the largest slum or "squatter" settlement in Asia (8,200 acres) out of which 1,300 acres were established by the KDA (Karachi Development Authority). The colonization starts in 1965 and extended swiftly in the mid-seventies. Most of the population belongs to low income groups having different ethnic and linguistic affiliations. On the north of Orangi town is New Karachi Town, in the east is, Gulberg Town, on the west is Sindh Industrial and Trading Estate (SITE) and Liaquatabad Town to the south. The water supply to Orangi town is mainly from Hub dam which is highly unpredictable. Orangi town also have illegal small industrial units (paints, plastic bags manufacturing, food factories and hosieries etc.,) which are being operated in informal sector. The present paper deals with the physicochemical and public health quality of piped water supply in Orangi town.

## MATERIAL AND METHODS

### *Sampling*

Samples from the tap water were collected deterministically by using rapid sampling approach from forty six sites of Orangi Town during March to August in 2014 and are presented in Fig 1. The samples were collected in pre-sterilized glass bottles (2 liters). The sample bottles were carefully filled to escape trapping air bubbles. The sample bottles were marked with specific codes, sealed and transported to the Institute of Environmental Studies, University of Karachi in cooled container.

### *Physico-Chemical parameters*

The samples were examined for pH, total suspended solids (TSS), total dissolved solids (TDS) and turbidity. pH and turbidity were determined on site by Hanna portable pH meter (HI98107) and EUTECH meter (Model No. TN-100) respectively. Gravimetric method was employed for TDS and TSS estimation[13].

Chloride was estimated by Argentometric method, hardness was ascertained by $CaCO_3$ (EDTA titrimetric method), sulphate was determined by gravimetric method while alkalinity was estimated titrimetrically. These parameters were estimated through theStandard Methods for the Examination of Water and Wastewater. Calcium, magnesium, potassium and Sodium were determined using flame photometry as described in APHA (2005)[13]. Residual chlorine was estimated by appropriate Merck kits.

### *Microbial analysis*

The microbiological examination of water samples was assessed for total coliforms count (TCC), total fecal coliforms (TFC) and total Fecal Streptococci (TFS). The water samples were analyzed in a laminar flow hood using sterilized bacterial culture media (Merck).TCC was assessed using single and double strength of lactose broth (Merck, Germany). From the positive lactose tubes EC medium (Merck, Germany) was inoculated for TFC determination. Sodium azide broth was used for TFS estimation [14]. The bacterial load of water samples was estimated by Most Probable Number (MPN) technique as per Standard Methods for the Examination of Water and Wastewater [13].

### *Statistical analysis*

The data was statistically analyzed using STATISTICA (99 Edition) software. Descriptive statistics including mean, median, minimum, maximum, standard deviation, quartile range and standard error were computed for each of the variables. Principal component analysis was applied on the normalized data sets of physical, chemical, and microbiological characteristics of tap water of different sites of Orangi Town. Cluster analysis and principal component analysis were performed using the appropriate software mentioned above. For cluster analysis, un-weighted pair group method was employed.

## RESULT AND DISCUSSION

As such no previous study pertaining to the drinking water quality of Orangi town is available to compare with.

From Table 1 it can be seen that the pH value ranges from 7 (OT-1, 6 and 22) to 7.5 (OT-18, 21, 38, 46) and the mean pH of all the samples was found to be 7.2 and within the permissible limit as per NSDWQ and WHO guidelines. This would mean that the pH of the drinking water is neutral.

Turbidity often determines the aesthetic quality of drinking water. According to WHO and NSDWQ the maximum allowable limit of turbidity is less than5 NTU. Mean turbidity values of all the samples were 0.54 NTU which is well within the limits. Turbidity values vary from 0.11(OT-13) to 0.91(OT-27) NTU. The high turbidity in water is mainly due to the presence of high-suspended solids that include silt, decaying plant and animal matter and suspended solids of both domestic and industrial origins. Turbidity originated from suspended solids can provide lodging for the microorganisms [15] that in turn causes health problems. Water with high turbidity from organic sources often increases the chlorine demand for disinfection [16].

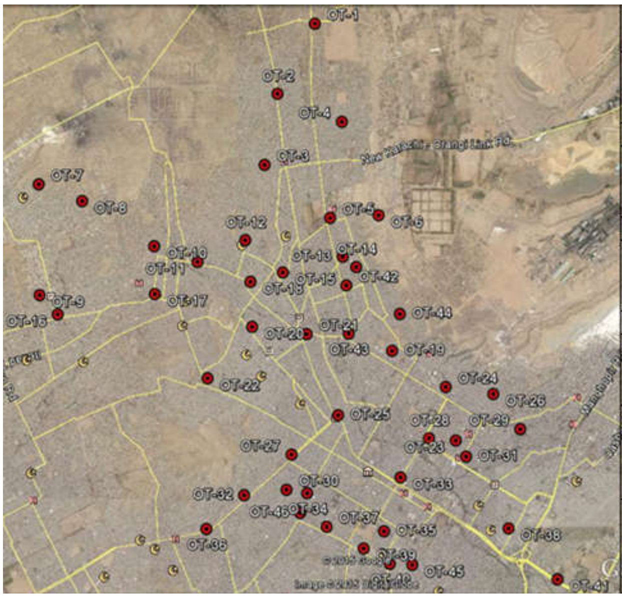
**Table 1 Descriptive statistics of physical, chemical and microbiological analysis of drinking water of Orangi Town, Karachi.**

| Parameters | Mean | Median | Min. | Max. | Quartile Range | Standard Deviation | Standard Error | *NSDWQ Standards | WHO guidelines |
|---|---|---|---|---|---|---|---|---|---|
| pH | 7.22 | 7.2 | 7 | 7.5 | 0.2 | 0.138 | 0.0204 | 6.5 – 8.5 | 6.5 – 8.5 |
| Turbidity/NTU | 0.54 | 0.6 | 0.11 | 0.91 | 0.51 | 0.256 | 0.0377 | < 5 NTU | 5 NTU |
| TSS (mg/l) | 153.5 | 156 | 108 | 192 | 40 | 23.658 | 3.4882 | N/A | N/A |
| TDS (mg/l) | 585.111 | 601 | 505 | 709 | 102 | 60.355 | 8.8988 | < 1000 | < 1000 |
| Calcium (mg/l) | 53.767 | 51.5 | 35 | 76.5 | 23.8 | 13.02 | 1.9197 | N/A | 100 |
| Magnesium(mg/l) | 110.537 | 108 | 62 | 168.8 | 29 | 23.078 | 3.4027 | N/A | 150 |
| Sodium (mg/l) | 30.659 | 32 | 19 | 40.1 | 10 | 5.736 | 0.8458 | N/A | 200 |
| Potassium (mg/l) | 4.928 | 4.85 | 4 | 6.5 | 0.9 | 0.597 | 0.0881 | N/A | N/A |
| Chloride (mg/l) | 112.326 | 108.5 | 100.7 | 131 | 15 | 8.514 | 1.2554 | <250 | 250 |
| Hardness (mg/l) | 164.304 | 159 | 121 | 232 | 32 | 23.468 | 3.4602 | <500 | N/A |
| Sulphate (mg/l) | 296.152 | 296 | 222 | 375 | 69 | 41.107 | 6.061 | N/A | 250 |
| Alkalinity (mg/l) | 129.391 | 126 | 90 | 160 | 23 | 17.093 | 2.5202 | N/A | 120 |
| Free Chlorine (mg/l) | 0.038 | 0 | 0 | 0.25 | 0 | 0.083 | 0.0122 | 0.2-0.5 | N/A |
| TCC (MPN/100ml) | 1734.043 | 2400 | 2 | 2400 | 1300 | 929.699 | 137.0766 | 0 MPN/100ml | 0 MPN/100ml |
| TFC (MPN/100ml) | 1155.196 | 460 | 2 | 2400 | 2190 | 1044.25 | 153.9662 | 0 MPN/100ml | 0 MPN/100ml |
| TFS (MPN/100ml) | 5.043 | 4 | 2 | 11 | 5 | 3.32 | 0.4895 | 0 MPN/100ml | 0 MPN/100ml |

*NSDWQ=National Standards for Drinking Water Quality, 2008, Ministry of Environment, Government of Pakistan
N/A= Not Available

Table 2 Results of PCA of physical, chemical and microbiological parameters of water samples

| Component | Eigenvalue | Percentage variance | Cumulative percentage variance | First 5 eigenvector coefficients | Associated variables |
|---|---|---|---|---|---|
| 1 | 3.1779 | 19.8619 | 19.8619 | 0.224288 | K |
| | | | | 0.179744 | TFS |
| | | | | 0.131028 | Mg |
| | | | | 0.031184 | pH |
| | | | | 0.001301 | $SO_4$ |
| 2 | 2.4895 | 15.5596 | 35.4214 | -0.193341 | Turbidity |
| | | | | -0.012610 | Ca |
| | | | | -0.090803 | $SO_4$ |
| | | | | -0. 073255 | pH |
| | | | | 0.005075 | TDS |
| 3 | 2.1440 | 13.4005 | 48.8219 | 0.127378 | Chloride |
| | | | | -0.121642 | K |
| | | | | 0.062631 | pH |
| | | | | -0.056354 | TFS |
| | | | | 0.043155 | TCC |



| Sample Code | GIS Coordinates | Sample Code | GIS Coordinates |
|---|---|---|---|
| OT-1 | 24° 59' 15.56" N, 66° 59' 30.21" E | OT-24 | 24° 57' 01.72" N, 67° 00' 24.74" E |
| OT-2 | 24° 58' 40.79" N, 66° 59' 14.65" E | OT-25 | 24° 56' 31.32" N, 66° 59' 39.88" E |
| OT-3 | 24° 58' 23.55" N, 66° 59' 09.30" E | OT-26 | 24° 56' 59.12" N, 67° 00' 44.54" E |
| OT-4 | 24° 58' 39.35" N, 66° 59' 41.30" E | OT-27 | 24° 56' 36.77" N, 66° 59' 20.30" E |
| OT-5 | 24° 58' 04.03" N, 66° 59' 36.60" E | OT-28 | 24° 56' 42.78" N, 67° 00' 17.82" E |
| OT-6 | 24° 58' 04.94" N, 66° 59' 56.76" E | OT-29 | 24° 56' 46.15" N, 67° 00' 55.84" E |
| OT-7 | 24° 58' 16.21" N, 66° 57' 35.73" E | OT-30 | 24° 56' 23.80" N, 66° 59' 18.39" E |
| OT-8 | 24° 58' 10.15" N, 66° 57' 53.51" E | OT-31 | 24° 56' 36.00" N, 67° 00' 33.33" E |
| OT-9 | 24° 57' 35.57" N, 66° 57' 35.57" E | OT-32 | 24° 56' 21.86" N, 66 59' 00.78" E |
| OT-10 | 24° 57' 33.57" N, 66° 58' 23.35" E | OT-33 | 24° 56' 28.29" N, 67° 00' 05.95" E |
| OT-11 | 24° 57' 47.81" N, 66° 58' 41.32" E | OT-34 | 24° 56' 22.36" N, 66° 59' 26.99" E |
| OT-12 | 24° 57' 55.82" N, 66° 59' 01.26" E | OT-35 | 24° 56' 08.44" N, 66° 59' 39.05" E |
| OT-13 | 24° 57' 40.73" N, 66° 59' 41.87" E | OT-36 | 24° 56' 09.31" N, 66° 58' 48.11" E |
| OT-14 | 24° 57' 45.92" N, 66° 59' 47.42" E | OT-37 | 24° 56' 10.16" N, 66° 59' 35.08" E |
| OT-15 | 24° 57' 43.94" N, 66° 59' 16.88" E | OT-38 | 24° 56' 09.42" N, 67° 00' 51.05" E |
| OT-16 | 24° 57' 28.44" N, 66° 57' 43.03" E | OT-39 | 24° 56' 02.11" N, 66° 59' 50.53" E |
| OT-17 | 24° 57' 35.95" N, 66° 58' 23.53" E | OT-40 | 24° 55' 36.40" N, 67° 00' 01.48" E |
| OT-18 | 24° 57' 40.31" N, 66° 59' 03.35" E | OT-41 | 24° 55' 50.46" N, 67° 01' 11.58" E |
| OT-19 | 24° 57' 15.03" N, 67° 00' 02.42" E | OT-42 | 24° 57' 39.15" N, 66° 59' 43.34" E |
| OT-20 | 24° 57' 23.90" N, 66° 59' 04.04" E | OT-43 | 24° 57' 21.36N, 66° 59' 44.32" E |
| OT-21 | 24° 57' 21.21" N, 66° 59' 26.80" E | OT-44 | 24° 57' 28.66" N, 67° 0' 5.61" E |
| OT-22 | 24° 57' 04.93" N, 66° 58' 45.56" E | OT-45 | 24° 55' 56.00" N, 67° 0' 10.81" E |
| OT-23 | 24° 56' 41.92" N, 67° 0' 28.97" E | OT-46 | 24° 56' 15.25N, 66° 59' 24.09" E |

Fig. 1. Sampling sites of the study area (Courtesy Google Map)

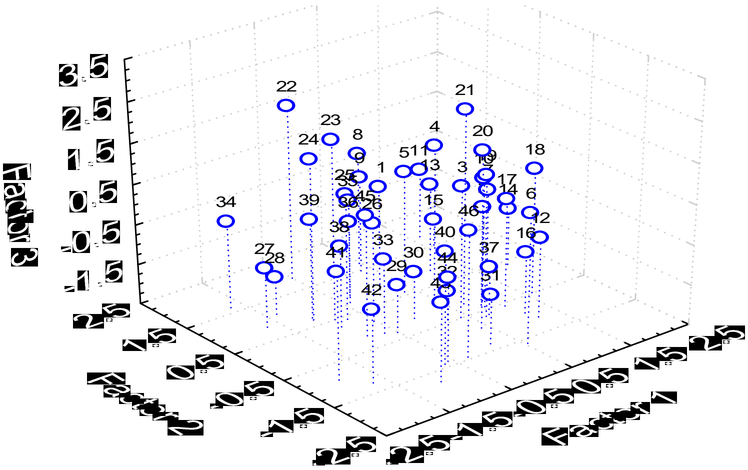


Fig 2 PCA ordination (3D) of physical, chemical and bacteriological parameters of water samples.

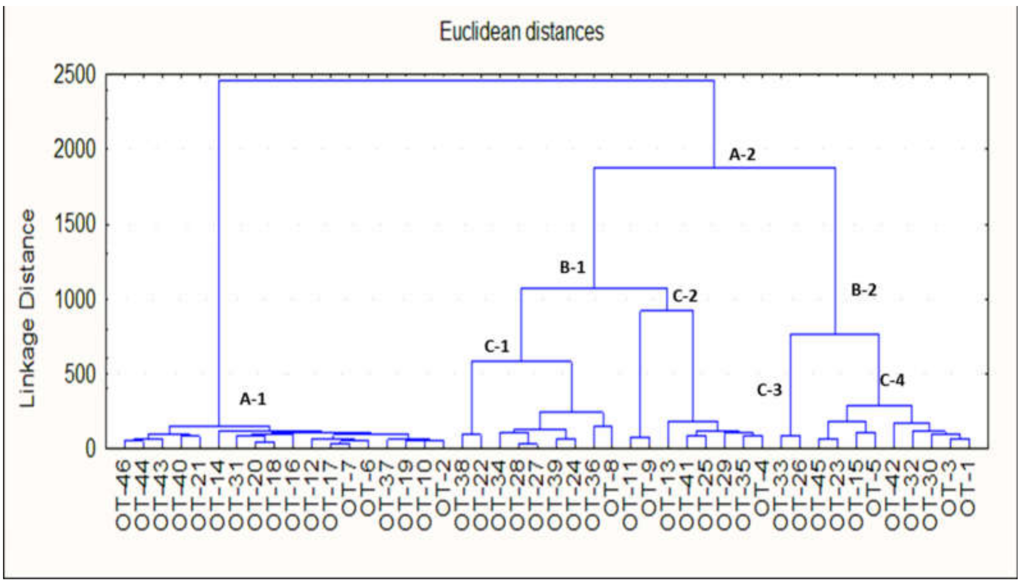



Fig.3: Dendogram derived from un-weighted pair group average between 46 sites based on Physical, chemical and bacteriological quality of water

The minimum and maximum TSS values were in the range from 108 (OT-13) to 192 (OT-42) mg/l. Mean TSS value of all water samples was153.50 mg/l. The mean TSS value was slightly higher than the permissible limit. OT-42 is the site have dilapidated hygienic and sanitary conditions. This site also has commercial activities. During the field visits it was observed that the manholes were over flowing which probably contaminates the water supply flowing through the obsolete network. High TDS concentration in water samples depreciates the palatability of water. In the present study, TDS values ranged between 505 (OT-41) to 709 (OT-16) mg/l while the mean value is 585.11mg/l. In general the TDS values were higher as compared to NSDWQ and WHO guidelines. The United States Environmental Protection Agency [17] recommends treatment of water having TDS concentrations > 500 mg/l.

Calcium is fifth most rich element present on the earth crust. It plays a significant role inhuman bones and cell physiology. Around 95% calcium in human body is deposited in teeth and bones. Inadequate consumptions of calcium have been linked with increased risks of obesity, osteoporosis, hypertension and stroke,, colorectal cancer, coronary artery disease, insulin resistance and nephrolithiasis (kidney stones)[18] while the over and above limit of calcium can produce cardiovascular diseases. It's permissible range in drinking water according to WHO standards is 75-250 mg/l. Conversely, an adult needs 1,000 mg per day to do work well. In the present study, the concentration of calcium ranged from 35(OT-20)-68.5(OT-36) mg/l with a mean concentration of 53.77mg/l (Table 1). Calcium quantity in Orangi town water supply is within the acceptable limit by WHO which is not harmful for local residents.

Magnesium is present naturally in water. It is the second plenteous cation in intracellular fluid and the fourth most abundant cation in the body. Human body contains about 25g of magnesium. Low levels of magnesium are linked with decreased insulin sensitivity, increased vascular reactions and endothelial dysfunction. Similarly low magnesium status has been implicated in metabolic syndrome, hypertension, type 2 diabetes mellitus and coronary heart disease[18].The acceptable range of magnesium in water should be 150 mg/l set by WHO. The mean value of Mg in water samples is 110.54 (Table 1). The Mg values were found to be within the permissible limit as per WHO guideline.

Concentration of sodium in potable water hardly exceeds to 20 mg/l. Adequate quantity of sodium in human body prevents kidney damages, hypertension, headache etc. The taste threshold of drinking water often associated with sodium and other associated anions. As such, no health based guideline value of Na is available. However, sodium concentrations of more than 200 mg/l may give increase to unacceptable taste [19]. The observed mean value in studied samples for sodium is30.66 mg/l (Table 1)which is under the permissible limits of WHO.

Potassium is necessary for living organism functioning. By following WHO standards, the allowable concentration of potassium is 12 mg/1. Results exhibited that the concentration of potassium in this study varies from 4-6.5 mg/l. Table 1 depicts the mean Potassium value which is 4.93mg/l. These results follow the WHO standards.

In drinking water, chloride comes from sewage and industrial effluents, urban runoff, natural sources and saline intrusion. The chief source for humans derives from the edible salt. It has significant importance for metabolism action in human body and other main physiological processes. The high amount of chloride may result in detectable flavor at 250mg/l but no health-related guideline value is recommended[19].According to NSDWQ the chloride value should be less than 250 mg/l. During the study chloride concentrations ranged from 100.7(OT-16) to 131 (OT-22) mg/l while the mean Chloride values obtained for all water samples is 112.33mg/l presented in Table 1which is well within the limits.

Hardness shows the collective amount of polyvalent cations whereas calcium and magnesium is the basic constituent of hardness [20] that is usually not harmful for humans. Permitting to WHO (World Health Organization) and NSDWQ guidelines, hardness of water should be less than 500 mg/l. concentration of Hardness above 500mg/L is generally unacceptable, although this level is tolerable in some communities [21].The observed mean value of total hardness for all water samples is164.30 mg/l. It varies from 121(OT-6)-232 (OT-15) mg/l (Table 1). Public adequacy of the degree of hardness may fluctuate noticeably from one community to another. These results indicate that the total hardness of water is according to the NSDWQ and WHO guidelines in addition it is not harmful for indigenous inhabitants.

The dissolution of salts of sulfuric acid generate sulfate which can be found in almost all water bodies. Concentration of sulfate in natural water varies from a limited to a some hundred mg per liter but no adverse consequence of sulfate on health of human is conveyed[22].The highest desirable limit of sulfate in drinking water set by WHO is 250 mg/l. However, the sulfate presence in drinking-water can cause obvious taste, and very high levels might cause laxative outcomes. It is usually considered that taste deficiency is minimal at levels lower than 250 mg/l.The mean value of sulfate is found to be 296.15 mg/l and varies from 222 (OT-1)-375(OT-43)mg/l (Table 1). The sulfate values were found to be higher than the WHO standard (250 mg/L) for drinking water[19].

Alkalinity is the capacity to neutralize acid. It is the existence of ions in water including bicarbonates, carbonates and hydroxides. Adequate concentration of alkalinity is acceptable in most water deliveries as it counter act the corrosive effects owing to acidity. Though, excessive amounts may cause a number of problems [22] particularly on heat exchangers, hot water systems, boilers and water heaters. The observed mean alkalinity value of water samples is 129.39mg/l (Table 1) that follows the WHO guidelines.

The chlorine values ranged from 0 to 0.25mg/l while mean chlorine values of all the samples was 0.038mg/l. Out of all the 46 samples chlorine was detected only in 9 samples (OT-21,OT-28 and OT- 34). These were the sampling station where the public health quality of water is relatively good.

The occurrence of coliform organisms shows the biological contamination of drinking water [23]. Detection of bacteriological contaminants of fecal origin is a main precedence in appraising the quality of drinking water. Drinking water contaminated with such microbes can cause ailments, such as cholera, diarrhea, typhoid,nausea and can even lead to death [24]. These effects may be more severe for adults,newborn babies and children with immune decencies [25]. The possible sources of such microorganisms include effluent from septic systems, storm water run-off, untreated sewage of domestic or wild animal fecal substance and infiltration. According to WHO, total coliforms and fecal coliforms must not be present per 100 ml water sample. From the Table 1 it can be seen that out of 46 samples only 9 samples were found to be fit for human consumption. The coliforms and fecal coliforms were exceptionally higher which an indication of fecal contamination is also. As per WHO standards (2011) treated water should have 0 coliforms per 100 ml therefore, the consumption of such water may poses serious health risks. The present results corroborate the findings of [26] in district Korangi, Karachi. The presence of coliform in water is mainly due to poor hygienic conditions prevailing in the area. The area has poor water supply and sewerage infrastructure. In fact both these systems are obsolete if not overloaded. The rusty pipelines of water sewerage system are running crisscrossed. Moreover, in many locations open drainage channel were found through which the wastewater seeps and contaminates the fresh water. Moreover, the Karachi Water and Sewerage Board people (Government agency responsible for water supply) often argued that the quantity of chlorine is adequate at the time of pumping. However, chlorine is being consumed during distribution because of heavy organic contamination form the sewerage network. The situation is not much different in other major cities of the country like Lahore, Karachi and Peshawar. In all these cities drinking water was found contaminated with microorganisms [27-31].

The result of PCA ordination is given in Fig. 2 and Table 2. The three dimensional PCA ordination shows a well-defined clusters. The first principal component explained 19.86 % of the variance, the second 15.55% while the third is 13.40%. Together the first three components explained 48.82% of the total variance. The first component is primarily a function of K, TFS, Mg, pH and $SO_4$. The second component is basically controlled by turbidity, Ca, K, $SO_4$, pH and TDS, while the third component is predominantly related to chlorides, K, pH, TFS and TCC.

The dendogram derived from un-weighted pair group method is given in Fig.3. Group 1 (A-1)includes eighteen samples. This group characterized by high TDS and sulphate values. Group 2 (A-2) comprises of the two sub groups namely B-1 and B-2. B-1 further subdivided into C-1 and C-2. C-1 comprises of 9 sampling sites is characterized mainly by moderate values of Na, K , high alkalinity values and low TCC and TFS with high chlorine value. Sub-group C-2 represent six sites and primarily a function low pH, TDS, Na and K. Sub-group B-2 further subdivided into C-3 and C-4. C-r characterized by six and shown high turbidity, high TSS and high Mg. C-4 shown five sampling sites with low pH, low Mg, low chloride and low alkalinity.

## CONCLUSIONS

Based upon the results it may be noted that the physico-chemical quality of the water supply is well within WHO guidelines and NSDWQ. However, major problem is associated with the public health quality. It is recommended that continuous monitoring of chlorine and organisms of public health importance should be carried out so as to maintain the residual chlorine of 0.2 to 0.5mg/l at consumer level. It is also recommended that the entire water and sewerage system need revamping to ensure the supply of potable water to the consumer.

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## REFERENCES

1. WHO, (2011). Guidelines for drinking-water quality. World Health Organization,Geneva.

2. PCRWR, (2005). Water Quality Report 2003–2004. (Pakistan Council for Research inWater Resources) National Water Quality Monitoring Programme. Islamabad, Pakistan.
3. Arnell, N.W., (2004). Climate change and global water resources: SRES emissions and socio-economic scenarios. Global environmental change, **14**(1): p. 31-52.
4. Briscoe, J. and U. Qamar, Pakistan's water economy: running dry. 2006: Oxford University Press Karachi.
5. UNDP, Pakistan National Human Development Report. "Water Crisis", Karachi. , 2003: p. pp 7 and 103
6. Khan, N., et al., Physiochemical evaluation of the drinking water sources from district Kohat, Khyber Pakhtunkhwa, Pakistan. Afr. J. Pharm. Phamacol.(Accepted for Publication), 2012.
7. Nabeela, F., et al., Microbial contamination of drinking water in Pakistan—a review. Environmental Science and Pollution Research, 2014. **21**(24): p. 13929-13942.
8. GWP, Global Water Partnership. Integrated water resources management TAC Background Paper no. 4. Stockholm: GWP., 2000.
9. MacDonald and Partners, (1985). Feasibility Study of Future Expansion of Karachi Water Supply System. MacDonald & Partners, &, Associated Consulting Engineers (ACE) Ltd, Karachi.
10. UN, (1988). Population Growth and Policies in Mega-cities: Karachi. Department of International Economic and Social Affairs, Population Policy.Unted Nations, New York, **Paper No. 13,**.
11. KWSB, (1994). Basic Facts: 1993–94. Karachi Water & Sewerage Board, Karachi,Pakistan.
12. Anon, (2000). Karachi Development Plan, United Nation Centre for Human Settlements. UNDP Project Pak/80/019,Karachi Master Plan 1986-2000, p. 20.
13. APHA,(2002). Standard methods for the examination of water and wastewater. 2005, American Public Health Association Washington DC., USA.
14. Mallmann, W.L. and E.B. Seligmann Jr, (1950). A Comparative Study of Media for the Detection of Streptococci in Water and Sewage*. American Journal of Public Health and the Nations Health, **40**(3): p. 286-289.
15. Aulicino, F. and F. Pastoni, (2003). Microorganisms surviving in drinking water systems and related problems]. Annali di igiene: medicina preventiva e di comunita, **16**(1-2): p. 265-272.
16. Crump, J., et al., (2004). Effect of point-of-use disinfection, flocculation and combined flocculation–disinfection on drinking water quality in western Kenya*. Journal of Applied Microbiology, **97**(1): p. 225-231.
17. US-EPA,(1978). Methods for the chemical analysis of water and wastes. US-EPA-625/6-74-003. Washington,DC: Office of Technology Transfer.
18. WHO, (2009). Calcium and Magnesium in Drinking-water: Public health significance. World Health Organization.
19. WHO, (2004). Guidelines for drinking-water quality: recommendations. Vol. 1. World Health Organization.
20. Mays, L.W., (1996). Water resources handbook. McGraw-Hill.
21. Koch, R., Zoeteman, BCJ: (1982). Sensory Assessment of Water Quality. Oxford-New York- Toronto- Sydney-Paris- Frankfurt, Pergamon-Press, 1980 148 S., 195 Lit. Acta hydrochimica et hydrobiologica, **10**(4): p. 322-322.
22. Mohsin, M., et al., (2013). Assessment of drinking water quality and its impact on residents health in Bahawalpur city. International Journal of Humanities and Social Science, **3**(15): p. 114-128.
23. LeChevallier, M.W., W. Norton, and R. Lee, (1991). Giardia and Cryptosporidum spp. in filtered drinking water supplies. Applied and Environmental Microbiology, **57**(9): p. 2617-2621.
24. Larmie, S. and D. Paintsil, (1996). A Survey of the Hygienic Quality of Drinking Water Sold in Accra. CSIR-Water, Accra
25. EPA, Drinking Water Contaminants. Environmental Protection Agency, Washington, DC., 2014.
26. Alamgir, A., et al., (2015). Prevalence of fecal contamination within a public drinking water supply in District Korangi, Karachi, Pakistan. Bull. Env. Pharmacol. Life Sci, **4**: p. 87-92.
27. Anwar, M.S., N.A. Chaudhry, and M. Tayyab, (1999). Bacteriological Quality of Drinking Water in Punjab: Evaluation of H~ 2S Strip Test. JOURNAL-PAKISTAN MEDICAL ASSOCIATION, **49**(10): p. 237-240.
28. Anwar, M., N. Chaudhry, and M. Tayyib, (2004). Qualitative assessment of bacteriological quality and chlorination status of drinking water in Lahore. Journal of the College of Physicians and Surgeons--Pakistan: JCPSP, **14**(3): p. 157-160.
29. Zahoorullah, A. T, and S. Zai, (2003). Quality of drinking water in rural Peshawar. Pak J Med Res, **42**: p. 85-89.
30. Mumtaz, M.W., et al., (2011). Estimation of bacteriological levels in surface water samples to evaluate their contamination profile. Environmental monitoring and assessment, **172**(1-4): p. 581-587.
31. Rahman, A., H. Lee, and M.A. Khan, (1997). Domestic water contamination in rapidly growing megacities of Asia: Case of Karachi, Pakistan. Environmental Monitoring and Assessment, **44**(1-3): p. 339-360.



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