JCBPS; Section D; November 2015 – January 2016, Vol. 6, No. 1; 36-48 E- ISSN: 2249 –1929

Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

Available online at www.jcbsc.org

Section D: Environmental Sciences

CODEN (USA): JCBPAT Research Article

Assessment of drinking water quality to investigate reasons behind water borne gastroenteritisat Tissar Village Tehsil Shigar, Baltistan Pakistan

Ajaz Ali, Khadim Hussain, Syed Jarrar Hussain,Nasir Hussain,

Environmental Protection Agency, Gilgit-Baltistan, Pakistan;Department of Environmental Sciences Karakorum International UniversityGilgit-Baltistan, Pakistan

Received: 18 November 2015; **Revised:** 08 December 2015; **Accepted:** 12 December 2015

Abstract: The present study was undertaken to investigate the reasons behind the water borne epidemic at Tissar Village Tehsil Shigar Baltistan. Some physical, biological and chemical parameters were examined from source, nallah, and water distribution network. Total seven sampling sites were selected for monitoring.Study was conducted during the second week of August2013 and water samples were taken using random sampling technique, from source, nallah, different mohallah (Prono and Thamocho) kohl locations andfrom different community taps. Water temperature, pH, electrical conductivity (EC), Turbidityof each water sample was measured using portable testing meters and personal sense of observations for specific parameters like color, odor and taste. Microbiological analysis was performed in situ using Waqtech Portable Water Testing Kit through Membrane Filtration (MF) technique recommended by WHO to analyze water samples to detect E. Coli as indicator of pathogenic microorganisms in drinking water samples. However chemical analyses (Nitrate and Nitrite) of samples were carried out by using HannaPhotometer. The test results of all the seven collected samples revealed that water is exceedingly contaminated with highest number of colonies (E. coli) up to 217 at Prono Mohallah Kuhl location 1 and not fit for drinking purposes according to WHO guidelines except the sample collected from the main nallah. Samples from Prono and Thamocho are also chemically contaminated with nitrates (65mg/l) thus exceeding the prescribed limits of WHO guidelines. Temperature ranged from 12°C to 20 °C, pH value recorded was 7-8, EC value was between 94.9-98.7, turbidity fluctuates between <40-<60 NTUs, color was cloudy while taste and odor were not objectionable. Sanitary inspection of channels and storage vessels showed that the water sources are highly contaminated with human and animal feaces. The main reason behind this contamination is traditional Chaksa and poor hygienic practices of the community.

Keywords:E. coli, Epidemic, Chaksa, National Environmental Quality Standards, World Health Organization, Environmental Protection Agency.

INTRODUCTION

Water quality is a rising global concern. Polluted water and insufficient sanitation kill two children every minute worldwide. Water quality is the physical, chemical and biological characteristics of water in relationship to a set of standards. The primary uses considered for such characterization are parameters which relate to drinking water, safety of human contact, and for health of ecosystem. Interest in water analysis is due to the massive importance of water to all categories of living things. It is necessary for the healthy development of man, animals and plants[1].As water contains minerals, important for human as well as for other living beings, so it is an essential component for survival of life on earth[2]. Water quality changes due to physical, biological and chemical conditions that occur as results of physical and anthropogenic activities[3]. According to Khan& Yaser[4] in Pakistan, a large percentage of rural and urban population does not have access to safe drinking water. During 2004 to 2005, about 38.5 million people in Pakistan lacked access to safe drinking water sources which may rise to 52.8 million people by 2015. About 200,000 children die annually as a result of diarrheal disease alone according to an estimate[5].

Moreover, reports also indicate that poor water quality is a cause of around 30 to 40 percent of all reported diseases and deaths in Pakistan respectively while diarrhea is major cause of deaths in infants and children under ten years of age[6]Drinking water quality has been debated throughout the world[7-8] .The usual source of drinking water is the streams, rivers, wells and boreholes which are mostly untreated and associated with various health risks[9].During a study conducted in Karachi, out of hundreds of samples of water no one was found safe for drinking purposes[10]). Another study in district Kohat (KPK) conducted by Ahmad *et al*[11].Analyzed 18 samples collected from different sites to test physiochemical parameters i.e. pH, TDS, alkalinity, Electrical conductivity etc. Results indicate that most of the samples were contaminated.According to Khalown[12], Water pollution in Pakistan is increasing rapidly by micro-organisms, agro-chemical wastes, municipal wastes and industrial wastes introduced into a distribution system through the raw water. It has been indicated that water pollution has become a serious problem in Pakistan.

According to a UNICEF report 20 to 40 percent beds are occupied in the hospitals of Pakistan by the patients suffering from water-related diseases.In terms of human health the most dangerous water pollutants are pathogenic microorganism[13]. It is estimated that 250 million cases of waterborne diseases are reported worldwide[14] and annually 25 million deaths are blamed due to waterborne diseases[13]. Diarrhea is a waterborne disease which affects 40% children under five years old. Due to prevalence of diarrhea among 1.5 billion cases in developing countries, 4 million ends with death[15]According to Basavaraja Simpi *et al*[16].It is very necessary to check quality of drinking water at regular intervals, because due to its contamination human population suffers from various water borne diseases. The main cause of water related diseases is the presence of pathogenic organism in drinking water. Water born infections such as diarrhea, Cholera, Typhoid, and Hepatitis are endemic in Gilgit-Baltistan. Various epidemiological studies and hospital records indicates high prevalence of water born infections in the populations, among which children are the most affected group[17].

MATERIAL AND METHODS

Sampling: Sampling activity for water quality assessment was carried out during the second week of August, 2013.Total four sampling points were selected and samples were taken through random sampling technique from source, Porono mohallah kohl location 1, Porono mohallah kohl location 2, and Porono mohallah community tap. Water temperature, pH, electrical conductivity (EC), Turbidity, of each water sample was measured using portable testing meters and personal sense of observations for specific parameters like color, odor and taste. Microbiological analysis was performed in situ using Waqtech Portable Water Testing Kit through Membrane Filtration (MF) technique recommended by WHO to analyze water samples to detect E. Coli as indicator of pathogenic microorganisms in drinking water samples. However for chemical analysis samples were transported as per recommended procedure to Environmental Protection Agency laboratory and analysis was carried out using Hanna Photometer.

PARAMETERS TESTED

Temperature:

Temperature of all the samples was measured by using thermometer provided by Waqtech Water Testing Kit.

PH:

Potatest pH meter provided by Waqtech Water Testing Kit was used to measure pH of water samples. First cap of pH meter was removed then “On” button was pressed. Electrode was dipped about 2cm in to the sample. After stirred once let to stabilize reading. pH reading was noted.

Turbidity:

Nephrometric Turbidity tubes were used to measure turbidity of water samples. First the three tubes were connected together, then water was poured gradually into the tubes. Look water from the top of the tube across at bottom of the tube. Read level of water where cross just disappear and recorded the value.

Electrical Conductivity:

EC of drinking water samples was calculated by using conductivity meter [18]. Electrode of the conductivity meter was dipped in each sample and conductivity of the sample was calculated when a flash has been appeared on the screen. Before taking each reading electrode was washed with distilled water and then dried with soft tissue papers.

Microbial Analysis:

Waqtech Water Testing Kit was used for microbial analyses, which employ the Membrane Filtration Technique and membrane Lauryl Sulphate Broth as medium. A 100ml volume of water was sucked through the membrane (fitted in the sterile membrane unit) with the help of Vacuum Pump. The membrane was then placed on the absorbent pad saturated with Membrane Lauryl Sulphate Broth in sterile Aluminum Petri Dish. The plates were than incubated for 18 hours at 40-44 C. After incubation period all yellow colonies on the membrane were counted and reported in per 100 ml of water.

CHEMICAL ANALYSIS

Nitrate: Using the dropper, filled the cuvette with 6ml of sample, up to half of its height, and replaced the cap. Placed the cuvette into the holder and closed the lid. Pressthe zero key. The display showed "-0.0-" and ready for measurement. Removed the cuvette and added the content of one packet of HI 93728-0 reagent. Replaced the cap and immediately shacked vigorously up and down for exactly 10 seconds. Continue to mix by inverting the cuvette gently for 50 seconds. Re-inserted the cuvette into the instrument. Pressed timer and the display showed the countdown to the measurement, waited for 4 minutes and 30 seconds and pressed Read. When the timer ends the meter performed the reading. The instrument displayed the results in mg/L of nitrate-nitrogen. Press up and down buttons to access the second level functions. Pressed Chem Frm key to convert the result in mg/L of Nitrate (NO_3-)

Nitrite: Select the Nitrite HR method. Filled the cuvette up to the mark with 10 ml of unreacted sample and replaced the cap. Placed the cuvette into the holder and close the lid. Pressed the Zero key which displayed "-0.0" and the meter is zeroed, ready for measurement. Remove the cuvette. Added the content of one packet of HI 93708-0 reagent. Replaced the cap and shacked gently until completely dissolved. Re-inserted the cuvette into the instrument. Pressed Timer which displayed countdown prior to the measurement, waited for 10 minutes and pressed Read? When timer ended the meter performed the reading. The instrument displayed concentration in mg/L of nitrite. Press up and down keys to access second level functions. Press Chem Frm key to convert the result in mg/L of Nitrogen-nitrogen (NO_2- -N) and Sodium Nitrite ($NaNO_2$).

RESULTS AND DISCUSSION

Temperature: According to Jayaraman *et al*[19]. The temperature drinking water is often not a major concern to consumers especially in terms of drinking water quality. The quality of water with respect to temperature is usually left to the individual taste and preference and there are no set guidelines for drinking water temperature. Examination of water samples taken from source nallah was 13°C while rest of all the samples has 18°C, 20°C,14°C, 19°C, 12°C, and 16°C respectively. Minimum temperature value recorded was 12°C and maximum was 20°C. The observed temperature variation of the sampled water from 9°C to 25 °C in a study conducted by Shedayi et al[20]at drinking water quality of Nomal, Gilgit-Baltistan, Pakistan. Of the seven samples one were at higher side. This deviation from limitation may be because of the timing of the sampling.

PH: pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity [21]. pH values recorded from source nallah was 7.6, while other values of pH recorded were

7.8, 7, 8, 6.6, 7.2, 7.7 respectively. WHO has recommended 6.5 to 8.5 value of pH for drinking water. Minimum 6.6 and maximum 8 pH values was recorded in the water samples.Similar results have been found in other countries by [22], pH values ranges from 7.5 to 8.4. The maximum pH value (8.4) was recorded in the month of April (summer) and minimum (7.5) in the month of October. The mean pH of private and public borehole water samples stood at 5.42 and 7.34 respectively in Nigeria by [23], in their study comparative analysis of public and private borehole water supply sources in urban local government area of Akwa Ibom state. Similarly, Shedayi *et al*[20].Recorded pH value of 7.1 in a study of drinking water quality of Nomal Gilgit-Baltistan Pakistan. It indicated that pH value of all collected samples fall within safe limit of drinking water quality in WHO standards while in this study the pH values were also within the prescribed limits of WHO.

Detail results of analyzed parameters are shown in **table 1**.

Table1: showing consolidated results of physio-chemical and microbiological parameter

S#	Sampling Location	PARAMETERS TESTED									
		Temp	pH	Turbidity	E. coli	EC	Color	Odor	Taste	Nitrate	Nitrite
1	Source (Nallah)	13°C	7.6	<60 NTU	0col	96.9	cloudy	No obj	No obj	22.7 mg/l	2.7 mg/l
2	Prono Mohallah kohl	18°C	7.8	<40 NTU	217col	98.7	cloudy	No obj	No obj	65 mg/l	4 mg/l
3	Prono Mohallah community tape	20°C	7	<47 NTU	170col	95.6	cloudy	No obj	No obj	48 mg/l	2 mg/l
4	Thamocho Mohallah location-1	14°C	8	<50 NTU	148col	98.6	cloudy	No obj	No obj	63 mg/l	4.4 mg/l
5	Thamocho Mohallah location-2	19°C	6.6	<54 NTU	168col	94.9	cloudy	No obj	No obj	61 mg/l	4 mg/l
6	Thamocho Mohallah location-3	12°C	7.2	<58 NTU	112col	96.2	cloudy	No obj	No obj	59 mg/l	4.3 mg/l
7	Thamocho Mohallah location-4	16°C	7.6	<56 NTU	121col	97.5	cloudy	No obj	No obj	60.2 mg/l	4.1 mg/l

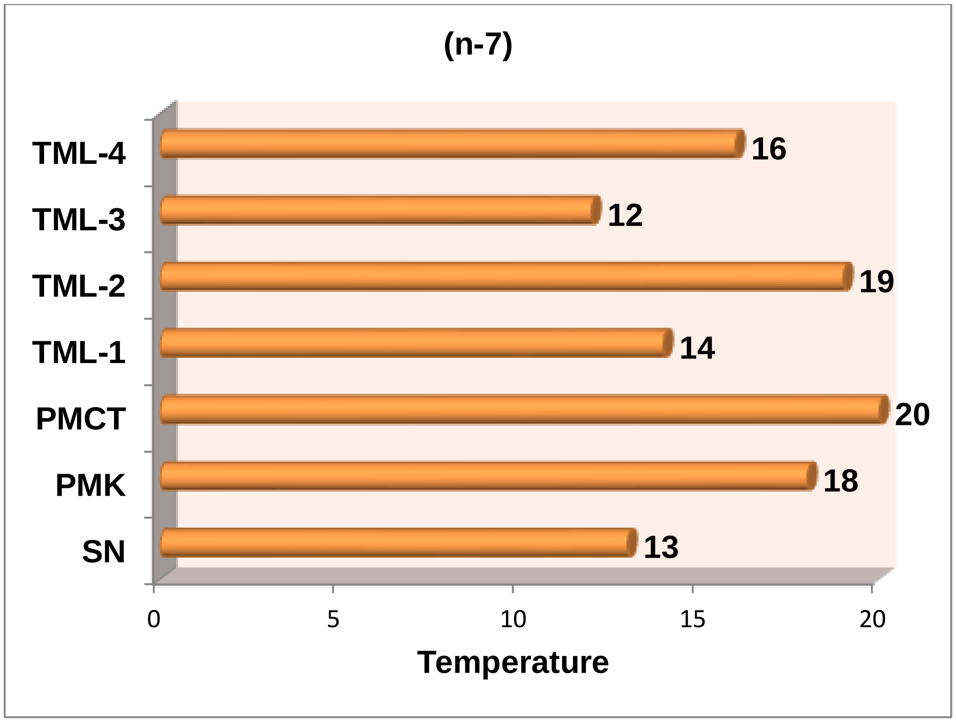

Fig 1: showing temperature levels at different sampling points

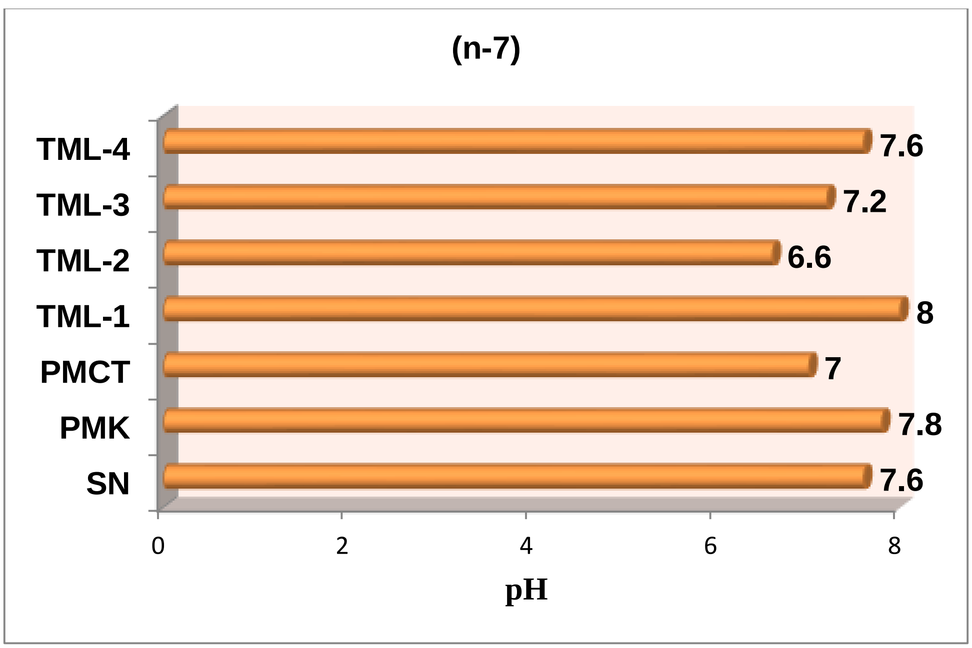

Fig 2: showing pH levels at different sampling points

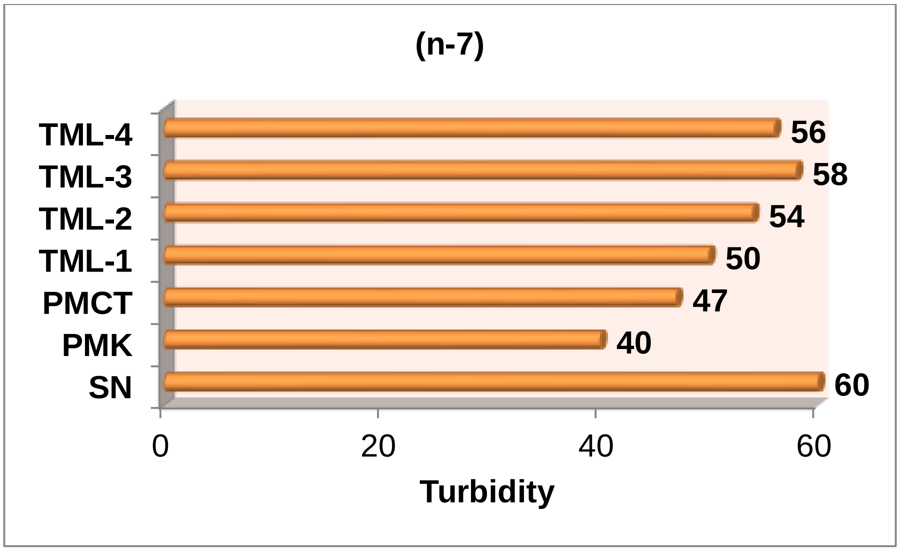

Fig 3: showing turbidity levels at different sampling points.

Turbidity:

Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, parasites that can cause nausea, cramps, and diarrhea and associated headaches[24].

Turbidity values observed from the water samples of source nallah was <60 NTUs, while turbidity level for rest of samples noted were <40 NTUs, <47 NTUs, <50 NTUs, <54NTUs, <58 NTUs, <56 NTUs respectively. A little fluctuation in the findings of tested samples was observed, varied between <40–<60 NTUs.Maximum turbidity value <60 NTUs was found at source nallah while lowest values <40 NTUs was found at Prono Mohallah kohl. According to WHO guidelines and NEQ standards the turbidity value should be <5NTUs and all the analyzed samples exceeding the prescribed limits.In a similar study by Naqvi *et al*[25]. turbidity value of the studied samples were exceeding the WHO guidelines as well as PCRWR values except for samples MF 05, 08, 10, 11, 12, and 14, which had the turbidity values within permissible limits.

Electrical Conductivity: Electrical conductivity is the ability of a material to conduct electric current in water[26].EC values determined from source nallah were 96.9µS/cm, while rest of sampling locations has98.7, 95.6, 98.6, 94.9, 96.2, and 97.5µS/cm respectively. Maximum value recorded was 98.7µS/cm and minimum was 94.9µS/cm.

According to WHO guidelineselectrical conductivityof drinking water must not exceed 400 µS/cm. EC values of all the analyzed samples were within the prescribed standards of WHO. Studies by other researchers[27-28]were also in accordance with the current study where Electrical conductivity of water samples was well within the permissible limit of WHO guideline of 400µS/cm.

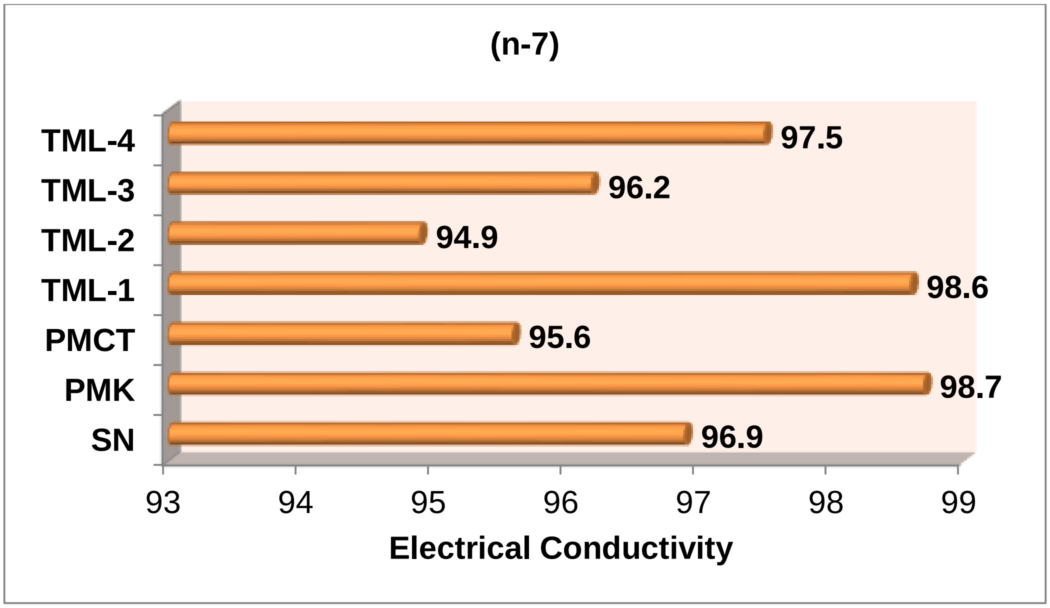

Fig 4: showing EC levels at different samplings points

Microbial Analysis: Total coliform bacteria and faecal coliform Escherichia Coli (E. coli) are two types of faecal indicator bacteria. Several bacteria can be classified as coliform, and are commonly found in soil, on the surface of leaves, in decaying matter, and can grow in water distribution mains[29]. In the current study faecal contamination were found in the samples with colonies (E. coli) up to 217 at Prono Mohallah kohl while at source nallah no colonies (E. coli) were found. A previous study conducted by Malick *et al*[30], (1998) analyzed the drinking water quality in the city of Karachi. Results showed the presence of Coliform bacteria in the main distribution lines. It indicates that water got contaminated from the surrounding leaky sewerage pipelines. Secondly, the presence of faecal Coliform in the water of branch lines feeding to consumers and stand posts, confirmed the mixing of sewage into drinking water lines making it unfit for drinking. Other studies by Shedayi *et al*[20] found 100 colonies in water tank, in tape1;15 colonies, in well 67 colonies, in channel 2;17 colonies and in tap2; 5 coliform were analyzed in 1 ml of water sample. Tahir *et al*[31] analyzed the drinking water quality in the rural areas of Rawalpindi. Most of the water samples were found unfit for drinking purpose due to the presence of Coliform and E. coli.

Nitrate and Nitrite: Contamination of drinking water by nitrate is an evolving public health concern globally. Nitrate in groundwater is of concern not only because of its toxic potential, but also because it may indicate serious ground pollution[32]. Ingested nitrate from dietary sources and drinking water can be converted to nitrite and ultimately to N-nitroso compounds, many of which are known carcinogens[33-34]. Maximum value of nitrate and nitrite recorded was 65 at Prono Mohallah Kuhl, 4.4 at Thamocho Mohallah location-1. Minimum nitrate level recorded was 22.7 at source nallah and nitrite level 2 at Prono Mohallah community tape respectively. Both nitrate and nitrite levels were exceeding the prescribed limits of HWO. In India a study was conducted by Simpi *et a1*[22].found of nitrate values ranged from 2.1 mg/l to 12.8 mg/l. Maximum value (12.8mg/l) was observed in the month of August and minimum (2.10 mg/l) in the month of December. Similarly, Begum *et al*[35.] investigated highest level of nitrates at residential area, bridge and junction point while lowest level was found at upstream and tank inlet. A similar level of nitrite was found at the same sampling points because there was no anthropogenic activities occurred.

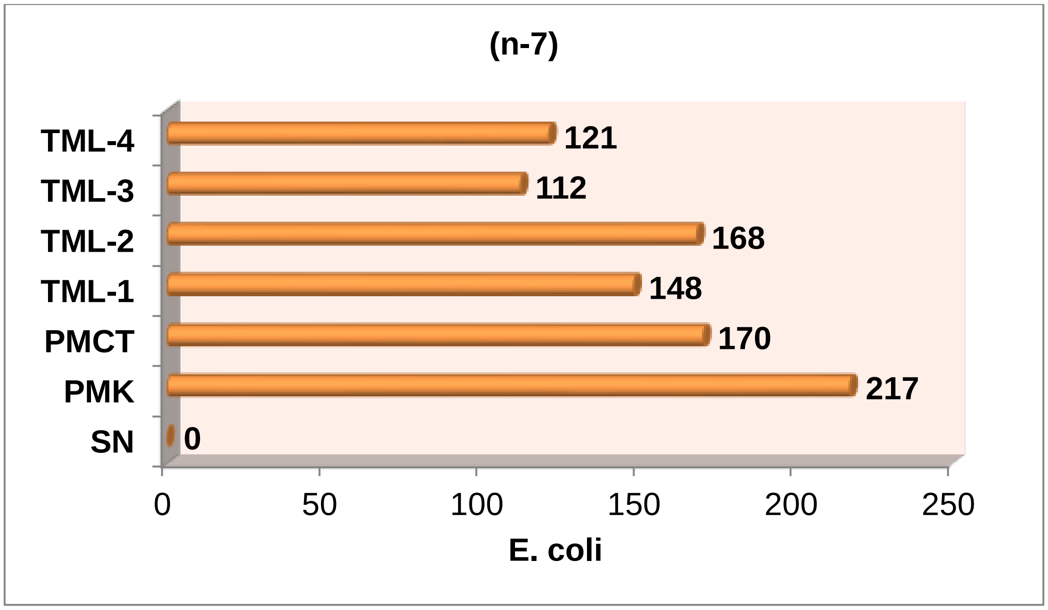

Fig 6: showing E. coli found in different sampling points

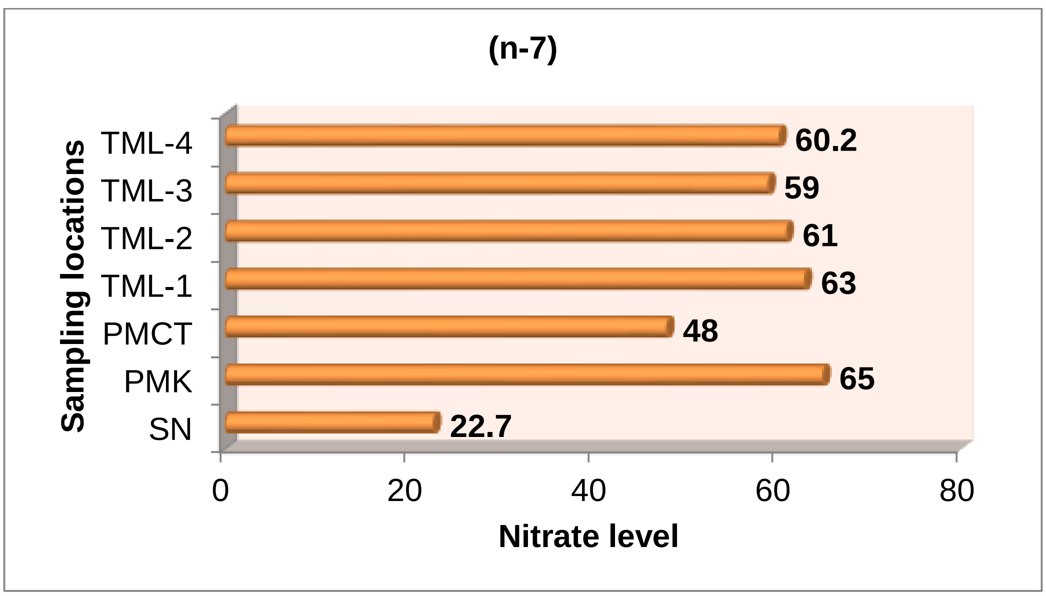

Fig 7: showing nitrate levels at different sampling points

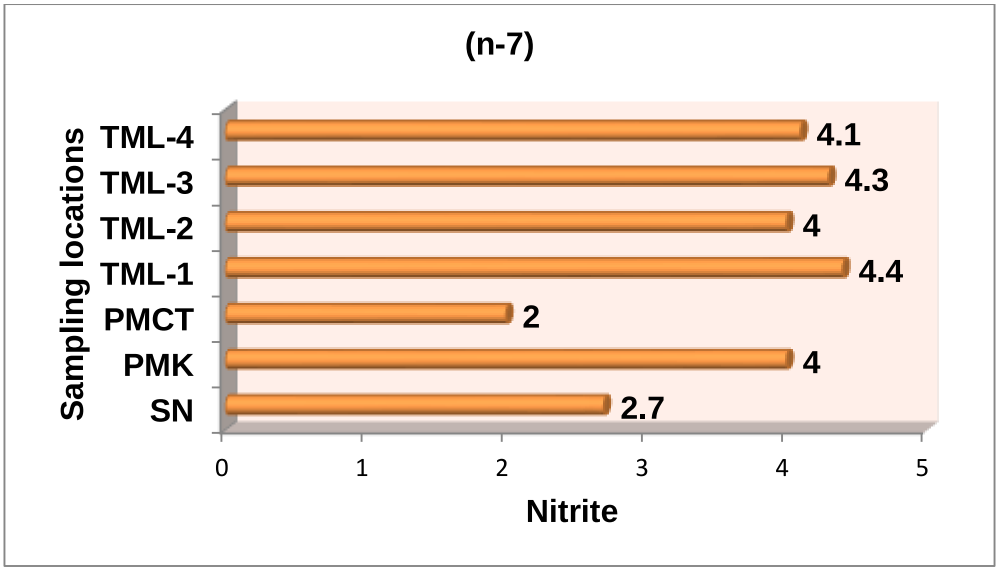

Fig 8: showing nitrite levels in different sampling points

CONCLUSION

Despite the availability of community piped water system and nallah the inhabitants of Tissar village are used to get water from small water channels running adjacent to local Chaksa and agricultural runoff which is highly contaminated with feacal matter. The most vulnerable group among community such as old aged and young individuals use water from these contaminated channels for ablution and washing. According to the test results and sanitary inspection of the water sources of the village transmission of gastroenteritis is due to the consumption of contaminated water, washing of utensil, improperly prepared foods or via close contact with individuals who are infected. The other reasons is sharing of personal objects and use of highly contaminated water for ablutions, bathing and washing etc.

RECOMMENDATIONS

- It is highly recommended that the water from small water channels should be used for drinking, washing, ablutions and bathing etc.
- Massive awareness sessions to be conducted among locals especially with the women folk which are most vulnerable.
- Provision of medicines i.e. antibiotics, antiemetic, oral and intravenous rehydration solutions and water disinfection tablets (chlorine tabs) on emergency basis.
- Health and hygienic education of local community can prevent transmission of epidemics in future.

ACKNOWLEDGEMENT

We appreciate Assistant Director (Lab/R&D) and Scientific Officer (Lab) Environmental Protection Agency for providing laboratory facilities, moral and technical support throughout the research work.

REFERENCES

1. K. Naveen Singh, Chemical analysis of ground water collected from different areas of Antiri and some nearby Villages, Current World Environment; 2007, 2 (1): 73-75.
2. A. Kumar, "Environmental chemistry", 5th Ed, New Age International (P) Limited; 2003, 4: 56.
3. D. Kar, P. Sur, S. K. Mandal, T. Shah, R.k. Kole. International Journal of Environmental Science and Technology; 2008, 5119.
4. J. Khan Faheem and J. Yaser, Delivering access to safe drinking water and adequate sanitation in Pakistan. 2007, (PIDE working papers No. 30).
5. N. Rosemann, Drinking water crisis in Pakistan and the issue of bottled water: the case of Nestlé's Pure Life. Action aid Pakistan; 2005.
6. http:// www.wwfpak.org/pdf/waterreport. (2007): accessed on January 2012.
7. E.G.D.Leoni, P.P.Legnani, R. Sacchetti, S.Spampi, F.Zanetti, Legionella Waterline Colonization: Detection of Legionella species in Domestic, Hotel and Hospital Hot Water System. J. Appl. Microbiol; 2005, 90 (2): 373-379.
8. R.Thurman, B.Faulkner, D.Veal, G.Cramer, M.Meiklejohn, Water quality in rural Australia. J. Appl. Microbiol; 1998, 84(4): 627-632.
9. P.O. Agbaire and C.G. Obi, Seasonal variation of some Physio-chemical properties of River Ethiope Water in Abraka, Nigeria. J. Appl. Sci. Environ. Manage; 2009, 13(1): 55-57
10. Ihsanullah, Evaluation and Prospects of Scientific Management of Water Resources in Karachi City: A GIS Perspective. Un-published PhD thesis. Department of Geography, University of Karachi, Karachi, Pakistan; 2009.
11. I.Ahmad, K.Bahadar, U.Hussain, A.Rehman, H.Iqbal, A.Wahab, A. Haq, U. Khan, M. A.F. Ijaz, Physico-chemical analysis of drinking water sources at sampling points of Billitang, Kda, Nasrat Khel and Chongee of District Kohat, K.P.K., Pakistan. International Journal of Science Innovations and Discoveries; 2012 2(6): 598-609.
12. M.A. Khalown, Water purification in rural areas. AJK National center for Rural Development, Islamabad; 2003, 7-8.
13. W.P. Cunningham, Environmental Science: A Global Concern. 8th Edn. McGraw-Hill, New York. 2005.
14. S.A. Esrey, R.G. Feachem and J. M. Hughes, Interventions for the control of diarrherial diseases among young children: Improving water supplies and excreta disposal facilities. Bull. WHO; 1985, 63 (4): 757-772.
15. Pakistan Environmental Protection Agency. Drinking water quality assessment in Karachi, Hyderabad and Kotri. Interim Report Environmental Protection Agency. Govt of Sind; 2005, Chapter 1, pp: 1
16. Basavaraja, S. M Simpi,K. N. S. HiremathMurthy, K. N. Chandra Shekarappa, N. Anil Patel, E. T. Puttiah, Analysis of Water Quality using Physicochemical parameters Hosahalli Tank in Shimoga District, Karnataka, India, Global Journal of Science Frontier, Research; 2011, 1(3): 31-34.

17. Environmental Protection Agency. Water and Waste water survey report in seven urban centers of Gilgit-Baltistan. Un-published report; 2012.
18. AOAC, Official Methods of Analysis Association of Analytical Chemistry, 18th Ed Virginia, 2000, 22201, Arlington, USA.
19. P. R Jayaraman, T. Ganga Deyi. and T.V. Nayar, Water quality studies on Karamana River, Thiruyananthapuram District South Kerela, India. Pollution Research; 2003, 22(1), 89-100.
20. A.A.Shedayi, Ahmad, M.Xu, S.Sadia, S.EhsanAndS. Riaz, Physiochemical and Bacteriologica. S l analysis of drinking water quality of Nomal, Gilgit-Baltistan, Pakistan. J. Bio & Env. Sci; 2015, 7(2): 81-87.
21. D. P.Gupta,J. P. Sunita & Saharan, Physicochemical analysis of ground water of selected area of Kaithal city (Haryana), India, Researcher; 2009, 1(2): 1-5.
22. B.Simpi, M. S.Hiremath, S.N.K.Murthy,N. K.Chandrashekarappa, N. A.Patel &T. E. Puttiah, “Analysis of Water Quality Using Physico-Chemical Parameters Hosahalli Tank in Shimoga District, Karnataka, India” Glob. Jour. of Sci. Front. Rese; 2011, Vol.11 Isu. 3 Vers. 1.0.
23. E. C. B. Ukpong, &B. Okon, “Comparative Analysis of Public and Private Borehole water supply sources in urban local government area of Akwa Ibom state” Int. Jour. of Apl. Sci. & Tech; 2013: 3(1).
24. Environmental Protection Agency (USEPA), Chemical contaminants in drinking water. Technical fast sheet on microbes. EPA; 2003, 816-03-016.
25. S.M. Naqvi,M.Taneez, &N. Khan, Physicochemical analysis of drinking water of Dhoke Dhamial (Mohra Fatima) Gujjar Khan, Pakistan. Int. J. of Adv. Sci. and Tech. Research; 2013, Vol. 6.
26. N. Rajvaid, &D. Markandey, Environmental analysis and instrumentation. Publ. A.P.H.Corp. New Delhi; 2005.
27. S.Asif, N.Sajjad, A.A.Sheikh, M.Shahzad, T.M.Munir, W.Umar, S. Umar, Assessment of water quality for drinking purpose from water coolers of different teaching institutes in Lahore, Pakistan. IOSR-JESTFT; 2015, 9: 18-22.
28. M.S.Yahya, A.Rahman, N.H.Abbasi, Assessment of seasonal and polluting effects on the quality of River Water by using Regression Analysis: A case study of River Indus in province of Sind, Pakistan. IJEP; 2012, Vol. 2No. Pp.10-16. www.ij-ep.org.
29. World Health Organization. Guidelines for Drinking Water Quality, Recommendation, 1996 Vol.1, pp.16-17.
30. Malick .F.K. W. Akhtar and J. Seema, Drinking water Quality in the city of Karachi, 24th WEDC Conference Sanitation and Water for all, Islamabad, Pakistan., 1998.
31. M.A.Tahir, B.A. Chandio, M. Abdullah and A. Rashid, Drinking water Quality Monitoring in the Rural Areas of Rawalpindi, National Workshop on Quality of Drinking Water. Pakistan Council of Research in Water Resources. Islamabad, Pakistan; 1998.
32. M.Nugent, M.A.Kamrin, L.Wolfson, D’ltri, Nitrate a drinking water concern. Michigan state University extension, Extension Bulletin WQ-19; 1993.

33. J.Sandor, I.Kiss, O.Farkas, I. Ember, Association between gastric cancer mortality and nitrate content of drinking water: Ecological study on small area inequalities. Eur. J. Epidemiol; 2001, 17(5): 443-447.
34. P.J. Weyer, B.J.Smith, Z.Feng, J.R.Kantamnenl, D.G.Riley, Comparison of nitrate levels in raw water and finished water from historical monitoring data on lowa Municipal drinking water supplies. J. Environ. Monit. Assess; 2006, 116 (1-3): 81-90.
35. F.Begum,K.Ali., Rubina, A.Khan, I.Hussain, S.Ishaq&S. Ali, Water quality assessment using macro invertebrates as indicator in Sultanabad stream (Nallah), Gilgit, Gilgit-Baltistan, Pakistan. J. Bio. & Env. Sci; 2014, 5(4): 564-572.

Corresponding author: Ajaz Ali;

Environmental Protection Agency, Gilgit-Baltistan, Pakistan;
Department of Environmental Sciences Karakorum International University,
Gilgit-Baltistan, Pakistan