EFFECT OF ABATTOIR WASTES ON SURFACE AND UNDERGROUND WATER QUALITIES IN YOLA METROPOLIS, ADAMAWA STATE, NIGERIA

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Abstract

The impact of abattoir effluent on the quality of surface and underground water in Yola Metropolis was studied. Water samples from Rivers, Wells and Boreholes were tested using standard analytical method for Temperature, Turbidity, Total Dissolved Solids, Electrical Conductivity, PH, Copper, Manganese, Sulphate, Iron, Zinc, Nitrate, Nitrite, *E. coli*, and Total Coliform. Water samples were collected from twenty different points with a control sample point. The result of abattoir effluent analysis revealed its pollution potential as it had ranges of the means values of all the parameters measured for Temperature 32.17-27.00°C, Manganese 2.1-1.2 mg/L, *E. coli* and Total Coliform were 58-6 and 78-27 cfu/ml respectively which were higher than WHO permissible limit. Part of the sample points of Turbidity, TDS, Electrical Conductivity, Iron and BOD were higher than that of the WHO maximum limits for effluent discharge into surface water. Pollution of ground and surface water through discharge of wastes is evidenced by the high concentrations of physico-chemical parameters and trace metals above the acceptable limits. It is recommended that a pretreatment system should be constructed before the discharge of the waste through a constructed lined drain to the nearby River Chouchi which is about 500m away.

Keywords: Abattoir wastes, Surface water quality, Ground water quality, Yola Metropolis

Introduction

The volume of water that is available in portable forms are sourced from the ground, springs, rivers, and lakes. About 71% of the earth's surface is covered with water, 97% of this water exists in oceans that are not suitable for drinking and 3% is fresh water. 2.97% of this fresh water can be found as glaciers and ice caps, and the remaining little portion of 0.03% is available as a surface and groundwater for human use (Behailu *et al*., 2017).

Pollution of water bodies is a serious environmental problem, especially in developing countries where there is improper waste management and the disposal of waste into water bodies. The World Health Organization [WHO] (2010) estimated that about a quarter of the diseases facing mankind today occur due to prolonged exposure to water pollution. One source of such water pollutants is abattoir effluent.

Water quality refers to the number of physical impurities, chemicals, dissolved gases, and pathogens in a given sample of water (Wurbs and James, 2010). The chemical composition of groundwater is an indicator of how suitable it is for the consumption of human beings, animals, and plants (Batabyal and Chakraborty, 2015).

Human activities impact natural water sources, including surface and ground water. One of such activities is the indiscriminate location of abattoirs in residential areas in developing countries (Elemile *et al*., 2019). Abattoirs all over the world are known to, directly or indirectly, pollute the environment through various processes (Neboh *et al.*, 2013). This is because less than 1% of the world's fresh water, or about 0.007% of the overall water on earth, is readily accessible for direct human use.

Abattoirs are usually located near water bodies in order to gain access to water for processing (Neboh *et al.*, 2013). The abattoir industry is a vital constituent of the livestock industry because it makes domestic meat available to over 150 million people and makes jobs available for many people in Nigeria.

Yola abattoir is not an exception, as it is located near River Chouchi (Akindawa, *et al.*, 2009). The mere location or establishment of an abattoir in an area, however, does not pose any environmental challenge, but when the abattoir is established without adequate facilities to properly manage its activities, it becomes detrimental to the environment and man. The wastes generated from abattoirs usually comprise blood, oil, mineral and organic solids, salts, and chemicals added during handling operations (Akange *et al*., 2016). It has now become the norm to either directly or indirectly dispose effluent from abattoirs into surface waters and soil in the area without any form of treatment. Abattoir activities require large amount of water, which equally brings about a large amount of wastewater at the end of its operations. Assessing the water quality within the vicinity of abattoirs in residential areas will help to anticipate the impacts on the health of residents who solely depend on the surface and ground water for consumption and other domestic uses (Elemile *et al*., 2019).

Materials and Methods

Yola metropolis of Adamawa State is in North-Eastern part of Nigeria. It lies between latitudes 7ºN and 11ºN of the equator, and longitudes 11ºE and 14ºE of the Greenwich Meridian. It shares national boundaries with Gombe on the West, It also shares an international boundary with the Republic of Cameroun by the East. The annual temperature ranges from 24.1ºC to 45ºC, the vegetation is that of Sub-Sudan vegetation marked by short grasses with short trees (Adebayo and Tukur, 1999). Yola Abattoir is in Yola South Local Government Area, with Tashan Sani as a closer community to the abattoir.

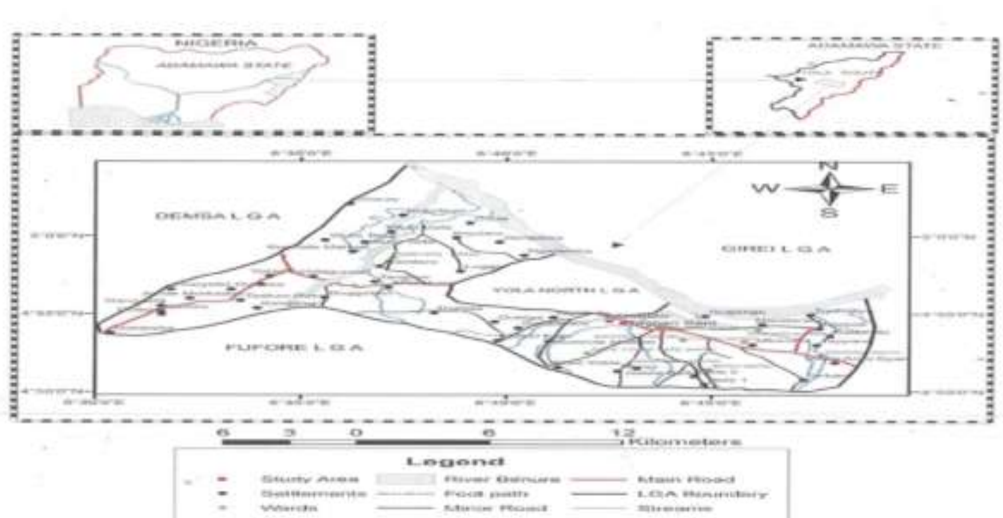

Figure 1: Map of Yola South L.G.A Showing Study Area

Samples Collection

Water samples were collected from twenty (20) points and a control point along River Chouchi, nearby wells, and boreholes for laboratory analysis. The control sample was about 100m upstream before the abattoir discharge point. The first sample point was the entrance of the abattoir effluent into the stream; the remaining points were points down the stream (4 points), dug well (5), and boreholes (10) in Tashan Sani. All the points were at intervals of at least 100m, and sampling was conducted at about 11:30 a.m. This time is specially chosen in order to allow the effluent from the abattoir to reach the stream. The samples were collected on four occasions for over four (4) weeks (i.e., five samples per week).

All bottles were washed with distilled water prior to use. At each sampling location, water sample were collected in a plastic container of two (2) liters. Before taking the water sample, the bottles were rinsed three times with the sample water at the point of collection to prevent any likely contamination from the containers used for the samples. All samples were labeled with the following information: (i) sample location (ii) date of collection and (iii) time of collection.

Laboratory Analysis of Water

The physico-chemical and microbiological analyses of the various water quality parameters were conducted using standard analytical methods, and the results were compared with World Health Organization permissible limits (WHO, 2011). This is because Nigeria is guided on environmental policy by the recommendations of the WHO and FAO.

The following heavy metals, Copper (Cu), Manganese (Mn), Iron (Fe) and Zinc (Zn) were analyzed using Atomic Absorption Spectrophotometer (AAS) Solar 969 Unicam Series Model. Each metal has a hollow cathode lamp for its determination. The instrument was set up at wavelengths specific to each element to be analyzed. Readings of the absorbance were obtained by observing the steady galvanometer reading in 2 minutes.

Microbiological analysis for Total coliform and *E. coli* was done using the method described by Chessbrough, 2006.

Results and Discussion

The results of the physical, chemical, microbiological and heavy metals characteristics of water samples determined were presented in table and charts below. Each parameter analyzed at different sampling points was shown and the values were compared with World Health Organization (WHO) recommended limits.

Sample Points	Temperature (^0C)	Turbidity (NTU)	TDS (mgl^{-1})	EC ($\mu S/cm^{-1}$)	PH	Copper (mgl^{-1})	Manganese (mgl^{-1})	Sulphate (mgl^{-1})	Iron (mgl^{-1})	Zinc (mgl^{-1})	Nitrate (mgl^{-1})	Nitrite (mgl^{-1})	E. Coli (cfu)	Total Coliform (cfu)
SC	30.83	1.31	159	318	7.36	0.13	1.6	0	0.58	0.14	1.8	0.002	19	52
S1	29.17	0.91	137	274	6.73	0.12	1.4	0	0.52	0.13	1.8	0.003	9	40
S2	28.83	0.35	244	488	7.02	0.14	1.2	0	0.5	0.11	1.7	0.003	7	50
S3	29.83	0.28	243	486	6.55	0.13	1.3	0	0.48	0.12	1.6	0.002	15	41
S4	27.16	0.22	257	514	6.94	0.13	1.4	0	0.5	0.13	1.7	0.003	8	48
S5	28.83	0.13	48	96	6.46	0.12	1.2	0	0.37	0.11	1.3	0.001	12	38
S6	27.33	8.11	38	76	7.2	0.57	2.1	12	0.09	0.11	6.1	0.043	40	43
S7	27.17	8.13	38	76	7.13	0.49	1.7	12	0.13	0.13	5.8	0.039	46	58
S8	27.67	8.08	34	68	7.17	0.68	1.8	15	0.13	0.1	4.6	0.039	39	68
S9	29.83	0.92	97	200	6.58	0.22	1.3	11	0.1	0.15	4.1	0.002	18	27
S10	28.17	8.13	37	74	7.03	0.41	1.6	13	0.23	0.18	5.2	0.033	58	72
S11	27.33	8.2	100	200	6.98	0.07	1.3	38	0.14	0.06	6	0.06	13	49
S12	27	8.1	59	118	6.72	0.06	1.4	32	0.07	0.17	5.3	0.04	6	38
S13	28.17	8	68	136	6.85	0.05	1.6	36	0.11	0.1	5.3	0.03	10	40
S14	29.17	8.1	78	156	7.67	0.06	1.3	30	0.09	0.09	5.5	0.001	20	78
S15	29	0.22	113	200	7.04	0.1	2	40	0.13	0.11	6.9	0.04	10	46
S16	29.17	0.26	115	230	6.87	0.06	1.4	41	0.08	0.18	7	0.06	9	56
S17	32.17	8.4	94	188	7.17	0.07	1.1	29	0.07	0.13	6.1	0.09	10	70
S18	28.83	8.8	40	80	7.39	0.08	1.2	32	0.04	0.15	6.3	0.05	18	36
S19	29.17	0.9	262	524	6.68	0.06	1.4	40	0.08	0.12	7.1	0.03	20	67
S20	29.83	0.85	109	218	6.65	0.11	2.16	42	0.13	0.1	7	0.02	15	59

Key:
TDS- Total Dissolved Solid
EC- Electrical Conductivity
E. coli- Escherichia coli
SC- Sample Control
S1-20 Sample Points

Temperature

From control sample down to sample 20, it was recorded higher temperatures. The lowest temperature was 27^0C, while the highest sampled temperature was $32.17^0{}_C$ at sampled point 17. All the sampled points were above the WHO recommendation limit of $25^0{}_C$ for drinking water.

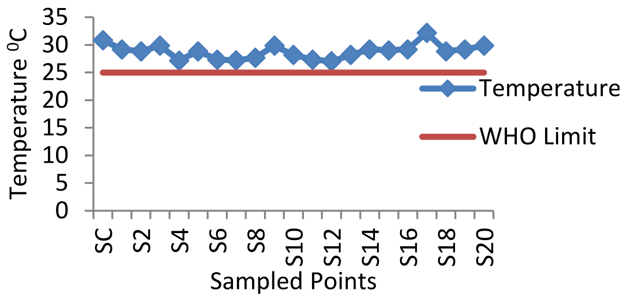

Fig 1: Temperature of sampled water at various locations

The temperatures obtained in the study exceeded the WHO standard of permissible limit; the study was in line with the research (Magaji and Chup, 2012). Temperature influences the amount of dissolved oxygen in water, which in turn influences the survival of aquatic organisms. The rates of biological and chemical processes depend on temperature. Aquatic organisms, from microbes to fish, are dependent on certain temperature ranges for their optimal health (Nafarnda *et al*., 2012).

Turbidity

From control sample down to sample 5, it was recorded as low turbidity. Turbidity increased from sample 6 downward. All the sampled points (except SC-S5, S9, S15, S16, S19 and S20) were above the WHO recommended limit for drinking water.

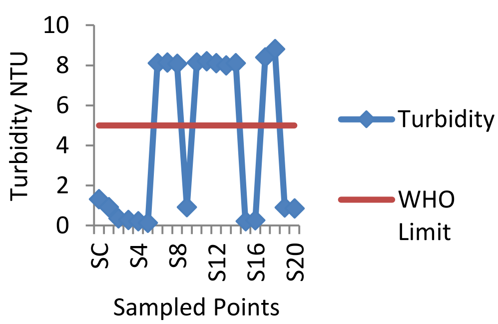

Fig 2: Turbidity of sampled water at various locations

The turbidity of the samples also exceeded the WHO permissible limit. It could be said that abattoir effluent contributed largely to the increase in turbidity at the sample points because the raw effluent had a high turbidity. The difference between the values of the control and other samples could be attrinuted to the distance. This is acceptable because the water would unlikely carry solids which might be responsible for some disease conditions (Chukwu, 2008)

Total Dissolved Solids

From control sample down to sample 4, it was recorded higher turbidity. Turbidity dropped from sample 5 downward and increased at S15 to S18 and increased at S19. Samples (SC-S4, S15, S16, S19 and S20) were above the WHO limit for drinking water.

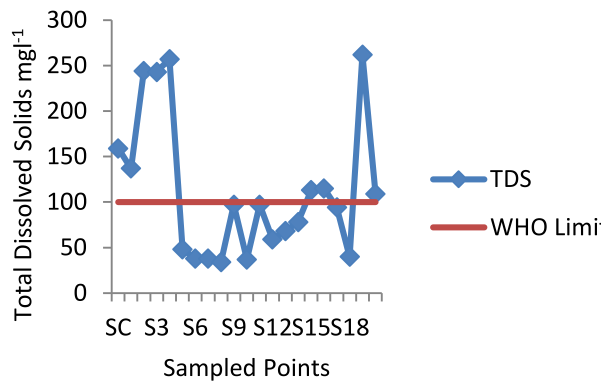

Fig 3: Total Dissolved Solids of sampled water at various locations

The Total Dissolved Solids (TDS) value of the result obtained from the analysis were beyond the WHO standard of <100 mg/L. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium and this interfere with the taste of foods and beverages and makes them less desirable to consume. The implication of a high value of TDS is that the water becomes undrinkable, and it can corrode containers used for water storage. The high values cannot be attributed to the abattoir but other sources pollution as the values of some samples were lower than the control sample (Elemile *et al*., 2019).

Electrical Conductivity

From control sample down to sample 4, it was recorded higher electrical conductivity. Electrical Conductivity dropped from sample 5 downward and increased at S15 to S16, dropped at S18 and rapidly increased at S19. Samples (SC-S4, S15, S16, S19 and S20) were above the WHO limit for drinking water.

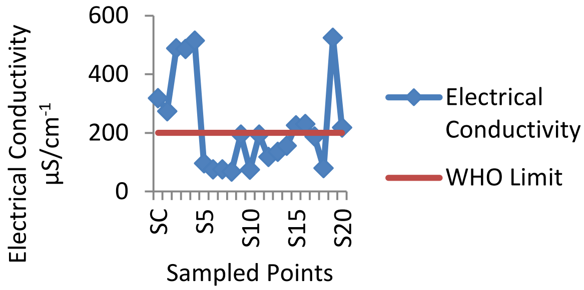

Fig 4: Electrical Conductivity of sampled water at various locations

The values of Electrical Conductivity from samples collected at points SC, S1-S4, S15, S16, S19 and S20 were above the WHO maximum permissible level. This is a measure of the dissolved ionic component and total dissolved substitution in water (Yilmaz and Koc, 2014). This shows that some of the water samples were saline, the concentration of salts dissolved in the water was a bit higher, and the salt content of a water body is determined by its ability to conduct an electric current. The consumption of the water, which has values above permissible limit over a period of time, has harmful effects on the health of man as it can defect the endocrine functions and cause total brain damage (Yogendra and Puttaiah, 2008).

PH

All the collected samples were tested below WHO limit for pH recommendations. The limit recommendation is between the ranges of 6.5-8.5, in which the sample with highest pH is 7.67 at sample point 14 while the lowest sampled pH is 6.46 at sample point 5.

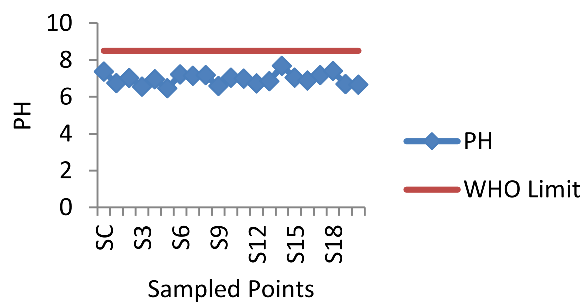

Fig 5: pH of sampled water at various locations

The pH is an indicator of the presence of microorganisms as it controls their activities. The pH values obtained fell within WHO standards compared with study of Masse and Masse (2000) on related study where all the samples were slightly alkaline. Therefore, the water samples were unlikely to cause health problems such as acidosis (Asamaoh and Amorin, 2011). However, pH played a significant role in determining the bacterial population growth and diversity in surface water.

Copper

All the collected samples were tested below WHO limit for Copper (Cu) recommendations. The limit recommendation is 1, in which the sample with highest Copper (Cu) is 0.68 at sample point 8 while the lowest sampled pH is 0.05 at sample point 13.

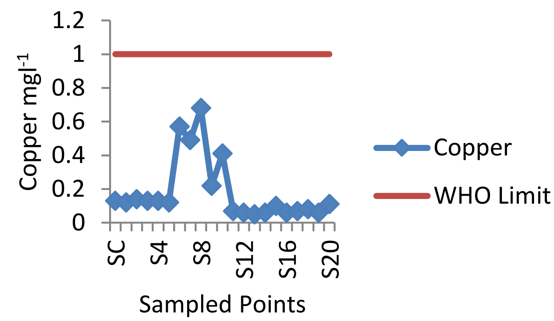

Fig 6: Copper of sampled water at various locations

It has been reported that high values of copper could result in chronic anemia (Iqbal *et al.*, 2011). Copper can contaminate drinking water either by directly polluting water sources or through the rust of copper pipes and materials.

Manganese

All the collected samples were tested above WHO limit for Manganese (Mn) recommendations. The limit recommendation is 0.05, in which the sample with highest Manganese (Mn) is 2.1 at sample points 6 and 20 while the lowest sampled Manganese (Mn) is 1.2 at sample point 2 and 18.

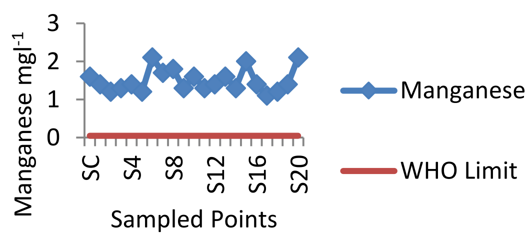

Fig 7: Manganese of sampled water at various locations

From the obtained result, the concentration of Manganese values above the WHO recommended value. Waterborne manganese has a greater bioavailability than dietary manganese. According to WHO, (2010), higher levels of exposure to manganese in drinking water are associated with increased intellectual impairment and reduced intelligence quotients in school-age children. However, data indicates that the human body can recover from certain adverse effects of overexposure to manganese if the exposure is stopped and the body can clear the excess (Amorin, 2011).

Sulphate

All the collected samples were tested below WHO limit for Sulphate recommendations. The limit recommendation is 100, in which the sample with highest Sulphate (SO_4^{2-}) is 42 at sample point 20 while the lowest sampled Sulphate is 0 from sample points SC to S5

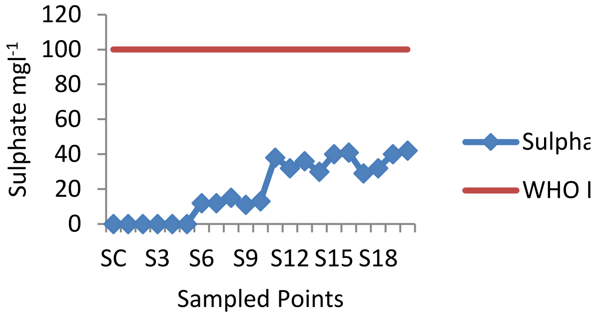

Fig 8: Sulphate of sampled water at various locations

The Sulphate values obtained fell within the WHO recommends that a concentration higher than 450 mg/L is unhygienic due to problems to the gastro intestinal tract. All the water samples collected had their Sulphate values lower than the recommended limit. This may be attributed to the depth and the concrete slab on which prevent abattoir effluents having access into them. Although, it has been reported that there is no guideline value based on human health; however, the recommendation of WHO is that any concentration higher than 100mg/L is termed un-hygienic (Yogendra and Puttaiah, 2008).

Iron

From control sample down to sample 5, it was recorded higher Iron contents. The rest are beyond the WHO limit for Iron recommendations. The lowest sampled Iron is 0.04, while the highest sampled Iron is 0.58 at Control Sample location.

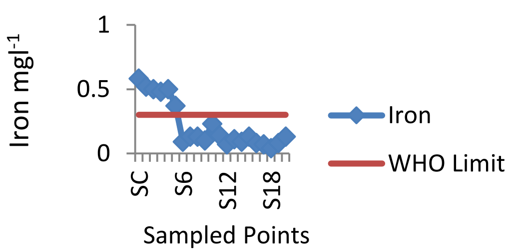

Fig 9: Iron of sampled water at various locations

Iron concentration in the collected samples from SC down to S5 were above the maximum contaminant levels of the iron content based on WHO (2010). This implies that if the abattoir discharges its wastewater into other water bodies used for drinking purposes downstream, it could be a contaminant and hence, hazardous to human health.

Zinc

All the collected samples were tested below WHO limit for Zinc recommendations. The limit recommendation is 5, in which the sample with highest Zinc (Zn) is 0.18 at sample points 10 and 16 while the lowest sampled Zinc is 0.10 from sample points 8, 13 and 20.

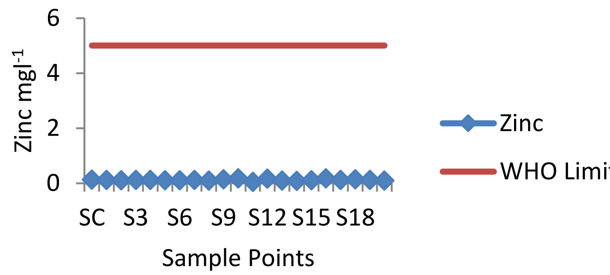

Fig 10: Zinc of sampled water at various locations

The concentrations of Zinc values were within the permissible limit of the WHO (2010). They were within the range reported for African inland waters. It has been reported that that acute zinc harmfulness in people includes nausea, lack of moisture, tiredness, weariness, abdominal pain, inability to coordinate the muscles, and failing kidney function. Chronic doses of zinc increase the risk of developing deformation of blood cells and could also damage the pancreas (Vaishaly *et al*., 2015).

Nitrate

All the collected samples were tested below the WHO limit for Nitrate recommendations. The limit recommendation is 10, in which the sample with highest the Nitrate is 7.10 at sample point 19 while the lowest sampled Nitrate is 1.3 at sample point 5.

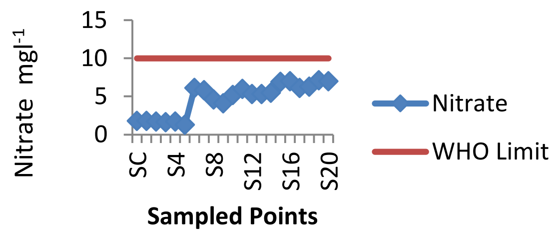

Fig 11: Nitrate of sampled water at various locations

Nitrate and nitrite are naturally occurring ions that are part of the nitrogen cycle. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater treatment, and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks (WHO, 2011). It has been reported that high values of nitrate could result in the blue-eye syndrome in little children and pregnant women. Also, high concentrations of nitrate and phosphate could lead to eutrophication (Adeolu *et al*., 2016).

Nitrite

All the collected samples were tested below the WHO limit for Nitrite recommendations. The limit recommendation is 1, in which the sample with the highest Nitrite (NO^{2-}) is 0.09 at sample point 17 while the lowest sampled Nitrite is 0.005 at sample point 5.

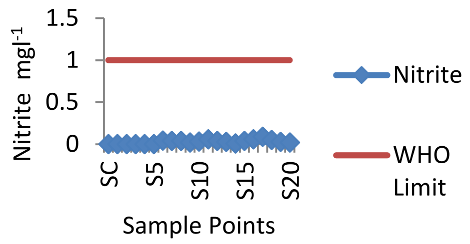

Fig 12: Nitrite of sampled water at various locations

Nitrite is a nitrogenous compound that when in excess in our drinking water can cause reduction of oxygen capacity of blood, shortness of breath, and blueness of skin (WHO, 2011). From the results obtained, the concentration values of Nitrate and Nitrite were below the WHO guideline values. High concentrations of nitrate in both surface and shallow groundwater can probably be due to poor sanitation and latrine construction, improper waste disposal, and other agrochemical uses.

E. coli

All the collected samples were tested above the WHO limit for *E. coli* recommendations. The limit recommendation is 0, in which the sample with the highest *E. coli* is 58 at sample point 10 while the lowest sampled *E. coli* is 6 at sample point 12.

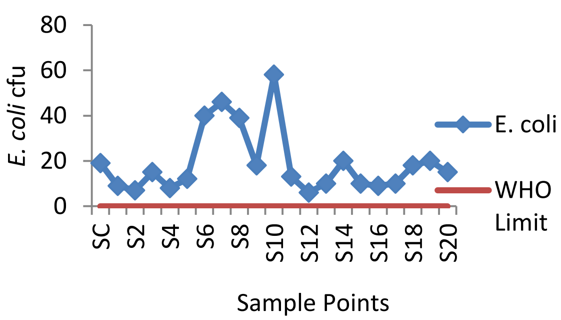

Fig 13: *E. coli* of sampled water at various locations

All the sampled points in both seasons contained *E. coli* at levels higher than the recommended limit with the highest recorded at the sample points. Consumption of the stream's water, however, can cause diarrhea and skin infections. *E. coli* may be found in water sources, such as private wells, that have been contaminated with faeces from infected humans or animals.

Total Coliform

All the collected samples were tested above the WHO limit for total coliform recommendations. The limit recommendation is 0, in which the sample with the highest total coliform is 78 at sample point 14 while the lowest sampled total coliform is 27 at sample point 9.

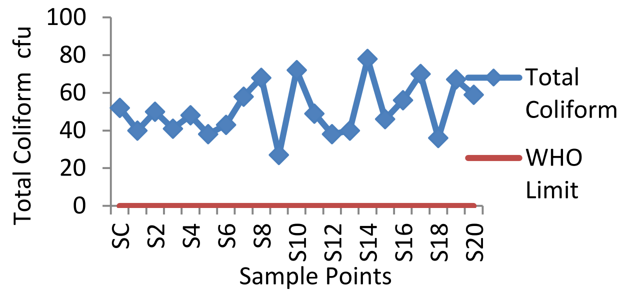

Fig 14: Total coliform of sampled water at various locations

The presence of total coliform provides evidence of recent fecal contamination, and the detection should lead to further action. From the total coliform values obtained. The presence of coliform reveals re-growth and possible bio-film function or contamination. They occur in both sewage and natural wastes and can also be excreted with human and animal feces. WHO (2010) recommends zero values for total coliform.

Conclusion and Recommendations

The study has shown that the discharge point of the abattoir raised some of the parameters and contributed to the increase in pollution load on the Chouchi River, wells, and boreholes. The level of *E. coli* and Total Coliforms are of special concern as they were below the detection limit at all sampling points. This calls for immediate attention, as the water sources are not safe for consumption. Furthermore, the concentration of heavy metals in the sample water was discovered to be significantly higher than the permissible limits (WHO standard, 2010). Although some of the results like, Copper and Zinc are in line with permissible limits (WHO standard, 2010). There is a likelihood for the residents within the vicinity of the abattoir to start experiencing severe effects from the pollutants from the operations of the abattoir located in their neighborhood. This calls for concern, as most of the analyzed values were above the recommended standards, which obviously signals danger to human health and that of plant life. Residents living in abattoir vicinity may in no distant time, begin to experience severe consequences from pollutants from abattoir activities located in their neighborhood.

In view of the findings of this research, and in addition to the fact that the abattoir is located in the heart of the town, and also, in view of the fact that the discharge of untreated abattoir wastes may continue unabated, it is therefore recommended that a pretreatment system be constructed before the discharge of the waste through a constructed lined drain to the nearby River Chouchi which is about 500m away. The discharge of the waste should be done after the segregation of waste materials had been done. In addition, new abattoirs should not be sited near residential area as, due to the potential impact on the surface and groundwater qualities.

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