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Assessment of Assela Town municipality waste water discharge effect on the chemical and bacteriological water pollution load of Anko River

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Assela, one of the developing towns in the south eastern central zone of Ethiopia, is located 175 km away from the Capital City of Addis Ababa. Anko River divides the town into two separate parts. In rural areas, water from Anko River is used for drinking and sanitation purposes. However, sewage from residential areas and Assela Hospital directly enters the river, affecting its quality. The objective was to determine Anko River water pollution status by the influence of wastewater discharge in Assela town. The cross sectional study design was conducted. The sampling techniques were wastewater samples taken from Assela Hospital waste water discharge site, upstream and downstream sites of Anko River for laboratory analysis in Addis Ababa. The average results of chemical and bacteriological parameters such as BOD_5 from 11.8 to 131.9 mg/L; COD from 115.7 to 206.2 mg/L, ammonia from 8.4 to 42.4 mg/L, nitrate varied from 1.6 to 3 mg/L, nitrite from 0.1 to 0.2 mg/L, and phosphate values varied from 2.1 to 6.3 mg/L, faecal coliform counts/100 ml varied from 180 to 600 and total coliform beyond WHO recommended for wastewater discharge. The correlations among the bacteriological and chemical properties were observed in the studied sites. Ammonia with phosphate, BOD_5 and COD had a significant positive correlation (r = 1.000, at P-value at 0.01, respectively). Nitrate had negative significant correlation with phosphate, BOD_5, COD and FCF(r = - 1 and -0.820, P-value < 0.01) and phosphate correlated with BOD_5, COD and FCF (r = 1 and 0.820, at P-value at 0.01, respectively). BOD_5 correlated with COD and FCF (r=1 and 0.820 with P-value at 0.001 respectively). Water borne diseases may be transmitted due to waste pollution of Anko River. Therefore, Assela town health departments have to take intervention measures on proper Anko River water treatment. Also, to reduce the faecal and total coliform organisms applying waste water treatment system with sand filtration followed by post chlorination systems must be recommended by Assela Hospital and municipality.

Key words: Water quality, indicator, water borne diseases, bacteriological and chemical water property.

INTRODUCTION

Wastewater refers to water whose quality is affected by the contribution of anthropogenic activities. Waste water discharged from agricultural activities, industries, residential houses, institutions and commercial areas

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pollutes drinking water sources (Akter et al., 1999.).

Health care waste generated from health care establishments like health centres, hospitals, laboratory offices, health post and clinics along with the composition of health care waste consists of organic and inorganic substance including microorganisms. Hospital waste had serious health hazard to the health workers, visitors, patients and nearby communities. The hospital waste is classified into infectious and general wastes (Akter et al., 1998) comprising both the liquid and dissolved substance generated within the hospital environment (FFEPA, 1991; Heen, 1999); the majority of general waste of non-hazardous particles such as kitchen waste, paper and plastics, whereas parts of human fetus, blood and body fluid, are hazardous pathological waste.

Infectious wastes are suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in large amount. They cause diseases in susceptible hosts, which include culture and stock of infective agents from laboratory waste, waste from surgery, etc; sharp waste, sharp items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Waste materials and pharmaceutical wastes cause damages to persons handling hospital equipment like knife, needle, broken glasses, and scalps. These wastes include pharmaceutical products (drugs and chemicals) that are returned from wards, contaminated or expired products; chemical wastes consist of discarded solid, liquid, and gaseous chemicals. They include diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. WHO (1999) reported that, about 85% of hospital waste is non-hazardous, 10% infective and 5% not infective.

United States of America, while about 15% of hospital waste is regarded as infective. In India, it was reported that the value could increase from 15% to 35% depending on the total amount of hospital waste generated, while in Pakistan about 20% of hospital waste could be found potentially infective or hazardous (Agarwal, 1998).

The public health significance of water quality must be considered from water borne disease transmission perspective. Many infectious diseases are transmitted by water through fecal-oral route. Diseases contacted through drinking water kill about 5 million children annually and make 1/6th of the world population sick (WHO., 2004). Water is vital to our existence in life and its importance in our daily life makes it imperative that thorough microbiological and chemical examinations be conducted on water. Potable water is water that is free from disease producing microorganisms and chemical substances that are dangerous to health (Lamikaran, 1999)

Sewage discharge is one of the problems presently facing South Africa and several efforts are being vigorously made to control it. Water contaminated by effluents from various sources is associated with heavy disease burden (Okoh et al., 2007) and this could influence the current shorter life expectancy in the developing countries compared to developed nations (WHO, 2002.).

Sewage discharges are a major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies; they promote toxic; algal blooms leading to a destabilized aquatic ecosystem (DWA and WRC, 1995, Morrison et al., 2001; DWA and WRC, 1995, Morrison et al., 2001, WRC, 1995).

At present, limited or no reports dealing with the water quality of Anko River had appeared in the literature. Hence, with the aims of assessing temporal variations and thereby encouraging public awareness of the water quality of the Anko River, the present chemical analysis and microbiological study was conducted to evaluate pollution caused by human influences along the river.

This study would help the consumers of Anko River water to understand the current quality status for under taking home made water treatment as immediate solutions of their surface water quality management systems. It also contributes the scientific way of reducing pollution generated by waste source controlled by Assela municipality.

This study also suggests that Assela Hospital should wake up to the current treatment of wastewater polluted in Anko River in order to improve surface water quality and to protect consumers' health.

Finally, it may direct interested professionals and stakeholders to undertake intervention on Anko River better surface water quality in the future.

The objective of this study was to determine Anko River water pollution status by the influence of wastewater discharge in Assela Town.

MATERIALS AND METHODS

Study area

Assela, one of the developing towns in the South eastern central zone of Ethiopia, is located 175km from the capital city of Addis Ababa. The town has fourteen kebeles. The town is crossed with one river, known as Anko which separate the town into two parts. In rural areas, Anko River water was used for domestic purposes. However, sewage from residential areas and Assela Hospital near the river was directly expelled into the river, thus affecting the water quality.

Study design

The cross sectional study design was conducted to assess the level of water pollutants from different sources. The water samples were analyzed by different laboratory investigation results in Addis Ababa. The result of every water chemical and bacteriological properties was taken for scientific analysis.

Sampling

Water samples were collected from the Assela hospital treated final

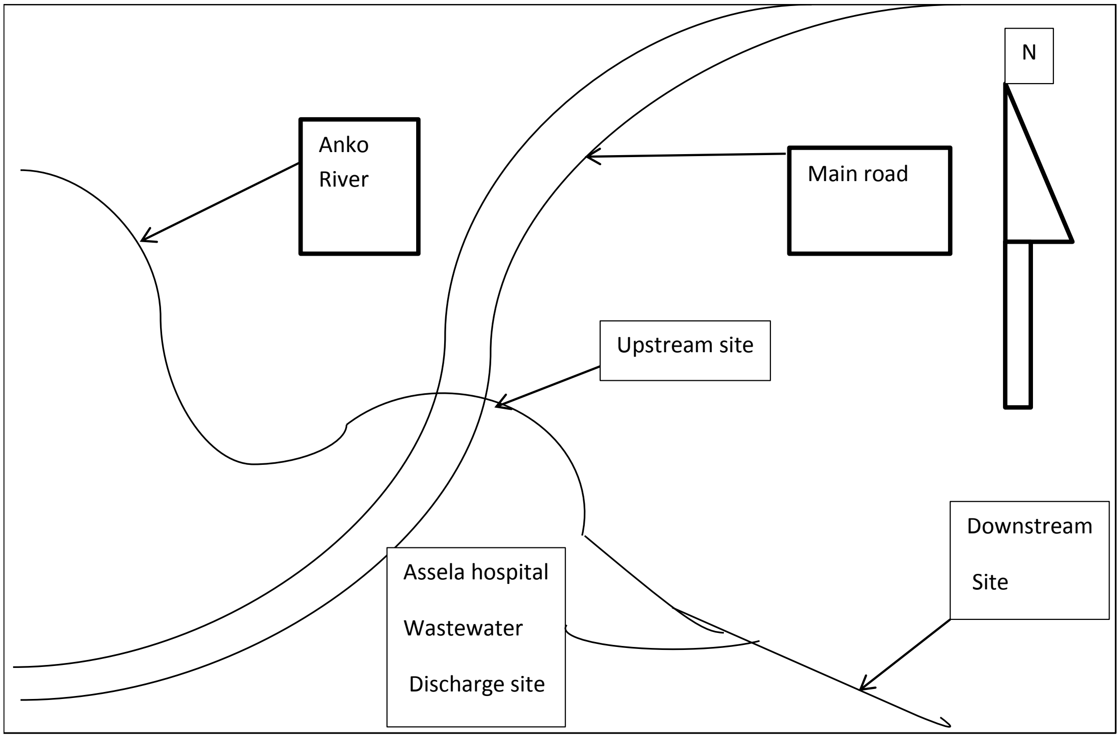

Figure 1. A sanitary survey water sampling site for laboratory analysis, Assela Town, November, 2012.

effluent, discharge point, 500 m downstream and upstream of the discharge point (Figure 1). Samples were collected monthly between April, 2012 and November, 2012. Samples were collected in plastic containers, pre-cleaned by washed and rinsed in tap water, 1:1 hydrochloric acid and finally with pure tap analysed wastewater.

Sampling technique

Before sampling, bottles were rinsed three times with sample water before being filled with the sample. The actual samplings were done midstream by dipping each sample bottle at approximately 20-30 cm below the water surface, projecting the mouth of the container against the flow direction. The samples were then transported in cooler boxes containing ice to Water Works Design and Supervision Enterprise Laboratory for analyses within 2 to 4 h after collection.

Chemical analysis

The concentrations of orthophosphate, nitrate, nitrite, ammonia , biochemical oxygen demand and chemical oxygen demand were determined in the laboratory by the standard spectrophotometric method (DWAF, 1999) using the spectroquant NOVA 60 photometer (Merck Pty Ltd).

Bacteriological analysis

Bacteriological characteristics were determined as described by Bezuidenhout et al. (2002). The most probable number- multiple tube technique was used for total and faecal coliform enumeration. SPSS version 20 software was used for carrying out the statistical analysis of the data.

RESULTS AND DISCUSSION

Ammonia generally arises from aerobic and anaerobic decomposition of nitrogenous organic matter. Urine of humans and animals yields large quantities of ammonium carbonate and hence sewage is rich in free ammonia. Average ammonia nitrogen contents of Anko River water at the tested sample stations were 8.4 to 42.4 mg/L (Table 1).

The maximum ammonia nitrogen was recorded in the second sample stations of hospital wastewater discharge site while minimum was at the upper stream site of sample station of the study sites (Figure 2).

Free ammonia, an indicator of aquatic pollution might be harmful to aquatic animals in Anko River mainly due to anthropogenic activities, municipal and sewage contaminations. In the present study, the concentration of ammonia- nitrogen was also found higher due to sewage discharge into the river by drains from hospital wastewater. The lower concentration of ammonia nitrogen was found at station A, a pristine site in the river.

Nitrate, the most highly oxidized form of nitrogen compounds is commonly present in surface and ground water because it is the end product of aerobic decomposition of organic nitrogenous matter. Unpolluted

Table 1. Average results of bacteriological & chemical laboratory analysis Water Works Design and Supervision Enterprise Laboratory Service Sub Process Water Quality Section from Anko river November, 2012GC.

Parameters	Up stream	Hospital wastewater treatment plant	Down stream
Ammonia (mg/L NH_3)	8.4	42.4	25.4
Nitrite (mg/L NO_2)	0.2	0.1	0.2
Nitrate (mg/L NO_3)	3	1.6	2.3
Phosphate (mg/L PO_4)	2.1	6.3	4.2
BOD_5 (mg/L)	11.8	131.9	106.3
COD (mg/L)	115.7	206.2	161
Total Coliform Per 100 ml	excess	excess	excess
Fecal Coliform Per 100 ml	220	600	180

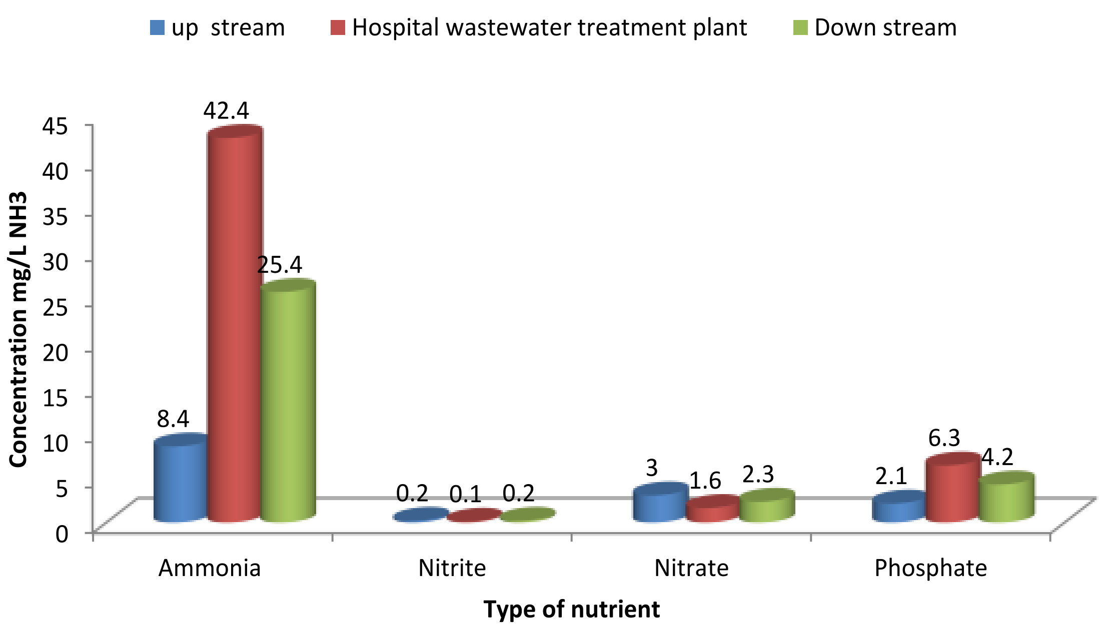

Figure 2. The laboratory result of nutrient concentration of Anko River, Assela Town, November, 2012.

natural waters usually contain only minute amounts of nitrate (Jaji et al., 2007). The average nitrate concentrations in each station are shown in Table 1. In this study, the nitrate-N concentrations ranged between 1.6 and 3 mg/L. The South African guideline for nitrate in sewage effluent is 1.5 mg/L NO3 - as N (Government Gazette, 1984).

The effluents did not meet this standard. It is important to note that nitrate level in the treated final effluent could be a source of Eutrophication for receiving water as the obtained values exceeded the recommended limit. The effluent from the treatment works might be considered as a source of nitrate into the receiving water body. The high nutrient levels in the upstream discharge point of the receiving water may be as a result of diffuse sources from settlement and agricultural runoff.

Nitrite levels in drinking-water are usually below 0.1 mg/l (WHO, 2011). The total nitrite levels obtained during the study period slightly exceeded the regulatory limits at upstream and downstream sites. Thus nitrite considered to pose a problem to communities when the receiving water body was used for domestic purposes. This may give rise to methaemoglobinemia (Fatoki et al., 2003).

However, it is important to note that the nitrite from the treated final effluents could be a source of Eutrophication for the receiving water bodies as the values obtained from the wastewater treatment plant exceeded the recommended limits for no risk of 0 to 0.5 mg/L as N (DWAF, 1996d) .

Nitrogen in the form of ammonia (NH_3) and nitrates (NO_3-) and phosphorus are essential nutrients to plant life, but when found in excessive quantities, they can stimulate excessive and undesirable plant growth such as algal blooms. Eutrophication could adversely affect the use of rivers and dams for recreation purposes as the covering of large areas by macrophytes could prevent access to waterways and could cause unsightly and malodorous scum which could lead to the growth of blue-green algae and release toxic substances (cyanotoxins) into the water systems. These substances are well known to cause the death of farm livestock (Holdsworth, 1991) and this must be a matter of concern in the Eastern Cape as this receiving water body is used for drinking by the farm livestock.

Moreover, it is well known that Eutrophication could increase the treatment cost of drinking water through filter clogging in water treatment works (Murray et al., 2000) (Table 1).

The orthophosphate –P contents varied from 2.1 to 6.3 mg/L. High phosphate levels were found in effluent zone of the second sampling stations than the other sites in receiving water body. The possible reason could be a consequence of Assela hospital wastewater dilution effect. However, the level of phosphate in water systems that would reduce the likelihood of algal and other plant growth is 5 μg/L (DWAF, 1996c). Other investigators had pointed out that Eutrophication-related problems in temperate zones of aquatic systems begin to increase at ambient total Phosphorous concentrations exceeding 0.035 mg/L. In warm-water systems, the values range between 0.34 and 0.70 mg/L (Rast and Thornton, 1996).

These represent nutrient threshold levels beyond which there had been a corresponding increase in the risk and intensity of plant-related water quality problems (OECD, 1982).

Comparison of the result obtained in this present study from the receiving watershed with some receiving water bodies, e.g. Keiskamma River (0.03 to 2 mg/L) (Morrison et al., 2001), Osun River (0.064 mg/L) (Olajire and Imeokparia, 2001) and Mukuvisi River (0.9- 11.7 mg/L) (Mathuthu et al., 1993) showed higher phosphate concentrations than that obtained in this study. In water quality studies, nitrogen and phosphorus are the nutrients most commonly identified as pollutants (Figure 2).

Biological oxygen demand

BOD determination is still the best available single test for assessing organic pollution. Singh and Rai, (1999) observed BOD of water samples value was indication for entry of organic waste in the River Ganga at Varansi and showed that high values are indication of organic pollution.

Lower levels of BOD at the sampling sites indicated that the Kistobazar Nala is not polluted by sewage disposal, animal waste, etc. and this could be attributed to sparse distribution of agricultural fields in its catchment area (Bhatt et al., 2001). Fokmare and Musaddiq, (2002) recorded high value of biochemical oxygen demand in Purna River and concluded that the river was highly polluted due to organic enrichment. Chavan et al., (2005) observed the creek water of Thane district (Maharashtra) showed high values of BOD and stated that the origin of these pollutants is mainly from the entry of effluents from surrounding industries. (Kelkar and Nanoti, 2005).

Higher level of BOD was observed by Tiwari et al., (2005). This may be due to sewage contamination in River Ganga at Bihar. Begum and Harikrishna, (2008) observed low level of BOD, indicating less pollution status of River Cauvery.

High levels of BOD were found in some areas of Haraz River at Iran mainly due to waste disposable at those sites (Keramat, 2008). Saksena et al., (2008) observed BOD ranged between 0.60 to 5.67 mg/L in Chambal River, and suggested that this stretch of the river was free from organic pollution. Anko River under study was BOD from 11.8mg/L at upper Station to 131.9 mg/L at lower Station (Figure 3). The second station which was Assela hospital wastewater discharge sites had a status of high organic pollution in the river.

Chemical oxygen demand

COD test is quite useful in finding out the pollution strength of industrial waste and sewage. Chemical oxygen demand is the amount of oxygen required for a sample to oxidize at its organic and inorganic matter. (Shrivastava and Patil, 2002) had observed COD value ranged from 74 to154 mg/L at Tapti River in Khandesh region. The value of COD showed that the water at Bhalgaon area in River Manjara, River Dhanegaon was not potable (Akuskar and Gaikwad, 2006).

Pillay, 2004) evident higher COD due to organic matter discharged by Fish farms and other sources like sewage. The effect of Ganga action plan was studied by Kelkar and Nanoti, 2005) and noticed the recovery of river health from organic load by reduction in COD values at Varansi.

Higher COD was observed by Chavan et al., 2005) in a stream at Thane district mainly due to pouring of industrial waste and municipal sewage. Tiwari et al., 2005) observed high level of COD in river at various places of Bihar mainly due to raw sewage, municipal waste, industrial effluents and anthropogenic disturbances.

In Gomati River at Sultanpur the COD is indicative of pollution in the river (Singh and Singh, 2007). The COD values fluctuated between 17.5 and 54 at River Cauvery showing beginning of organic pollutants (Begum and Harikrishna, 2008). Higher organic load at Haraz River, Iran at certain points is due to waste water discharge by some fish farm (Keramat, 2008). Marchese et al., 2008) noticed COD between 48 from 51 mg/L showing creation of pollution due to nearby industries and human disturbances through infrastructure works at Salado River (Argentina). Little abundance of COD in Kosi River, Uttrakhand indicates the pristine nature and good health of river (Bhandari and Nayal, 2008). In Anko River,

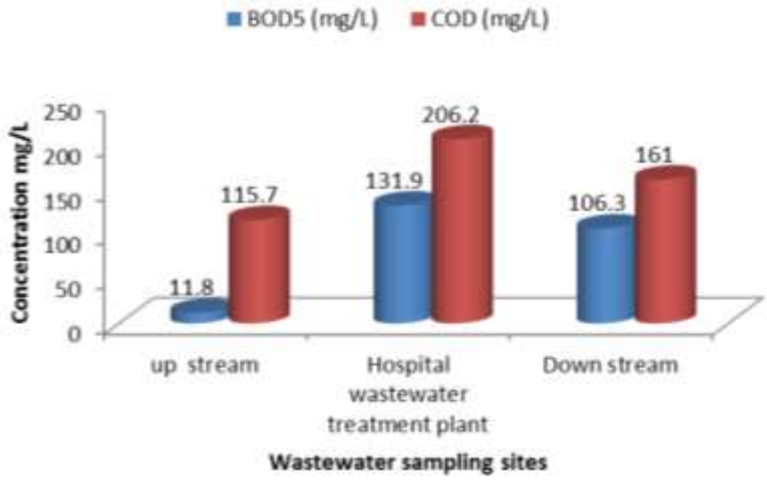

Figure 3. The laboratory result of chemical water parameter of anko river, Assela Town, November, 2012

Table 2. Pearson correlations among the bacteriological and chemical properties Anko River water in Assela, November, 2012.

Correlation	Stations	Ammonia	Nitrite	Nitrate	Phosphate	BOD_5	COD	TCF	FCF
Stations	1	0.500	0.000	-0.500	0.500	0.500	0.501	-0.682	-0.086
Ammonia		1	-0.866	-1.000**	1.000**	1.000**	1.000**	0.292	0.820
Nitrite			1	0.866	-0.866	-0.866	-0.866	-0.731	-0.996
Nitrate				1	-1.000**	-1.000**	-1.000**	-0.292	-0.820
Phosphate					1	1.000**	1.000**	0.292	0.820
BOD_5						1	1.000**	0.292	0.820
COD							1	0.292	0.819
TCF								1	0.787
FCF									1

**: Correlation is significant at the 0.01 level (2-tailed).

maximum COD was recorded as 206.2mg/L at the second station as it receives high pollution load.

The correlations among the bacteriological and chemical properties of water are studied and the results are presented in Table 2. There was no significant correlation observed between Ammonia and changes in TCF. But Ammonia with Phosphate, BOD_5, COD and FCF exhibited a significant positive correlation (r = 1.000, 1.000, 1.000 and .820 at P-value < 0.01, respectively).

Ammonia with Nitrite and NO_3 - indicated a negative correlation(r = -0.866 and -1.000, P-value < 0.01). Nitrite was negatively significantly related with phosphate, BOD_5, COD, TCF and FCF (r = -.866, -0.731and -0.996 P-value < 0.01). Also, nitrate exhibited negative significant correlation with phosphate, BOD_5, COD and FCF(r = - 1 and -0.820, P-value < 0.01) and phosphate positively correlated with BOD_5, COD and FCF (r = 1 and 0.820, at P-value < 0.01, respectively). BOD_5 positively correlated with COD and FCF (r=1 and 0.820 P-value <0.001 respectively) (Table 2).

This would help to understand the nature of these bacteriological and chemical variables and their species speciation in the effluent and receiving watershed. It was generally known that an increase in concentration of pollutants will occur during low flows when point sources dominate.

Bacteriological analysis

Heterotrophic count (HPC) measures a range of bacteria that are naturally present in the environment (EPA, 2002). The total bacterial counts for all the water samples were generally high exceeding the limit of $1.0X10^2$ cfu/ml which is the standard limit of heterotrophic count for drinking water (EPA, 2002). The high total heterotrophic count is indicative of the presence of high organic and dissolved salts in the water. The primary sources of these bacteria in water are animal and human wastes.

These sources of bacterial contamination include surface runoff, pasture, and other land areas where animal wastes are deposited. Additional sources include

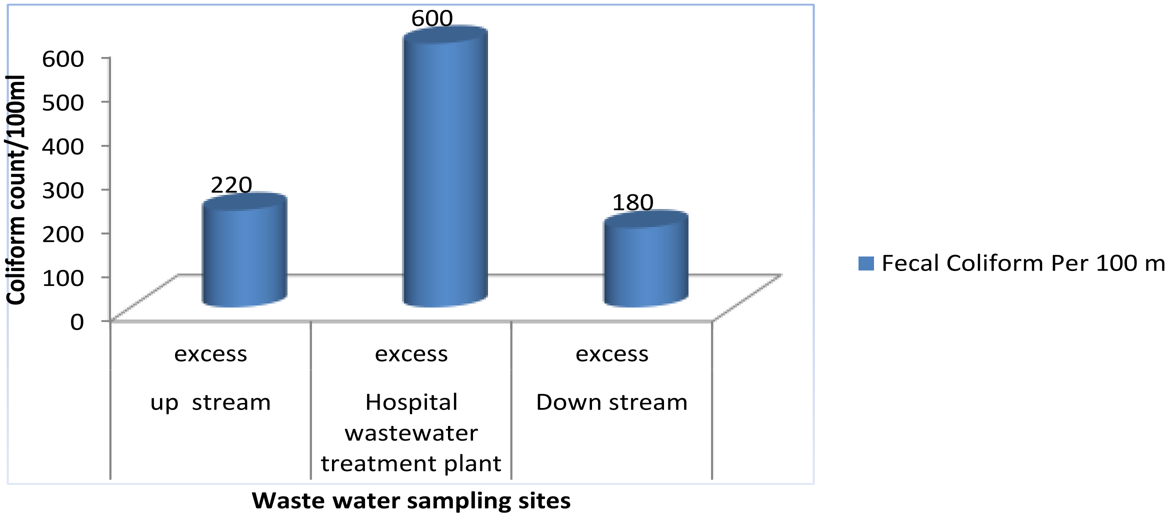

Figure 4. The laboratory result of bacteriological indicator organism in Anko River, Assela Town, November, 2012.

seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria (EPA, 2002). These contaminants were reflected in the highest bacterial load obtained in this study for the Anko River (Figure 4).

Accordingly, the total coliform counts for all samples were exceedingly high; the EPA maximum contamination level (MCL) for coliform bacteria in drinking water of zero total coliform per 100ml of water (EPA, 2003). The high coliform count obtained in the samples may be an indication that the water sources are faecally contaminated (EPA, 2003, M.I. and Eneuzie, 1999). None of the water samples complies with EPA standard for coliform in water.

According to EPA standard, every water sample that had coliform must be analyzed for either fecal coliforms or *E. coli* (EPA, 2003) with a view to ascertaining contamination with human or animal waste and possibly pathogenic bacteria or organism, such as *Gardia* and *Cryptosporidium* may be present (EPA, 2003).

CONCLUSION AND RECOMMENDATION

Proper waste water treatment, control of anthropogenic activities to prevent raw sewage from entering water body would be the key to avoiding bacterial contamination of drinking water. It was evident that water borne diseases were due to improper disposal of refuse, contamination of water by sewage, surface runoff, therefore Assela town health departments must be organized to educate the risk populations on the proper disposal of refuse, treatment of sewage and the need to purify our water by homemade water treatment, to make it fit for drinking because the associable organisms were of public health significance being implicated in one form of infection or the other.

In areas lacking in tap water as in rural dwelling, educative programmers must be organized by researchers and government agencies to enlighten the villagers on the proper use of surface water. Assela municipality would have to strengthen hygiene and sanitation activities to control untreated waste water discharge to surface water sources like Anko River. Assela Hospital waste water treatment was not completely effective treatment system. So to reduce the faecal and total coliform organisms additional treatment system with sand filtration followed by post chlorination systems constructions must be recommended urgently. Other private agency and stakeholders can also apply waste water treatment principles with the implementations of environmental health law of public health proclamations, 2000GC.

Abbreviations

BOD, Biochemical oxygen demand; **COD,** chemical oxygen demand; **EPA,** Environmental Protection Agency; **FCF,** fecal coliform count; **HPC,** heterotrophic count; **MCL,** maximum contamination level; **TCF,** total coliform count; **WHO,** World Health Organizations.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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