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RESEARCH ARTICLE

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Efficiency of University of Eldoret Wastewater Treatment Plant, Kenya

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Abstract

Wastewater treatment is a challenge that has afflicted man ever since he discovered that discharging pollutants into aquatic ecosystems have many detrimental ecological, environmental and health problems. Unsafe disposal of wastewater has become a serious threat to human and environment health. Release of untreated or partially treated wastewater is common especially in developing countries, due to lack of finances, infrastructure, technical and institutional capacity. This research was carried out to establish the efficiency of University of Eldoret wastewater treatment plant. Wastewater samples in the inlet and outlet of this plant were analyzed for physicochemical and bacteriological parameters, eutrophic nutrients and heavy metals using standard methods for a period of eight consecutive weeks. Eutrophic nutrients were determined using UV Vis spectrophotometer while heavy metals were determined using Atomic Absorption Spectrometer. The levels of these parameters obtained at the outlet were compared with the National Environmental Management Authority-Kenya standards for effluent disposal to the environment. The results for the influent and effluent were as follows; DO 0.44 -1.75 mg/l, 3.03-5.29 mg/l respectively, pH 6.83 - 8.30, 6.87 - 8.5 respectively, BOD 432 – 1396 mg/l, 32 – 58 mg/l respectively, COD 1204 – 2654 mg/l, 116 -156 mg/l respectively, feacal coliforms 57083 – 73367 cfu/100 ml, 28337-50043 cfu/100 ml respectively, phosphate 4.53-4.98 mg/l, 3.0 - 4.50 mg/l respectively, nitrates 3.95 -17.03 mg/l, 1.47- 6.17 mg/l, respectively, cadmium 0.044 - 0.109 mg/l, 0.088 - 0.109 mg/l respectively, copper 0.026 - 0.728 mg/l, 0.029 - 0.741 mg/l respectively, manganese 0.485 - 0.724 mg/l, 0.556 - 1.01 mg/l, respectively, cobalt 0.016 - 0.184 mg/l, 0.006 - 0.205, respectively, nickel 0.005 - 0.170 mg/l, 0.040 - 0.208 mg/l respectively, zinc 0.242 - 0.661 mg/l, 0.207 - 0.319 mg/l respectively, iron 0.421-3.0 mg/l, 0.377 - 0.956 mg/l, respectively, lead 0.0 - 0.057 mg/l, 0.06 - 0.153 mg/l respectively, chromium 0.0 - 0.014 mg/l. BOD, COD, coliforms, lead and cadmium were not compliant to the NEMA-Kenya standards which are 30 mg/l, 50 mg/l, 30 cfu/100 ml, 0.01 mg/l and 0.01 mg/l, respectively. The wastewater treatment plant was therefore not efficient. There is need to remove the over accumulated sludge in the stabilization ponds. The routine maintenance practices should be carried out and regular monitoring of the effluent done. The wastewater treatment plant needs to be upgraded in order to handle the increased wastewater volume.

Keywords: Influent, Effluent, Wastewater, Treatment, Efficiency

INTRODUCTION

There is an increasing concern for the diminishing supply of clean and potable water. The amount of utilizable water is scarce on earth and is further threatened by climate change that is predicted to alter the frequency, intensity and unpredictability of precipitation with negative effects on water availability. According to WWAP (2017), water scarcity is identified as the global risk of the highest concern for humankind and economies. To curb the problem of water shortage, various approaches have been employed to reduce water consumption, but the most sustainable solution is to recycle wastewater into high quality water.

Wastewater is an essential resource that can be recycled and reused to address the problem of water scarcity. Recently, the demand for freshwater has increased while its availability is decreasing due to over-abstraction, pollution and climate change. A lot of pressure on water resources are intensifying the need for the enhanced recycling of wastewater. In the face of the ever-growing demand for water, the reuse of wastewater is gaining popularity as the source of fresh water diminishes. In some parts of the country, wastewater is being used as a reliable alternative source of water for irrigation. Indeed, some communities are nowadays viewing wastewater as a resource that can provide solutions to their day to day challenges (WWAP, 2017).

Wastewater management and sanitation are regarded as capital-intensive. The problem is further escalated by lack of investment in human resource development (Roston *et al.*, 2017). Consequently, much of the wastewater is untreated or partially treated and discharged in aquatic ecosystems. Disposal of untreated wastewater can have adverse effects on flora and fauna. It can lead to the outbreak of food, water and vector-borne diseases (United Nations, 2017). It also leads to pollution and the loss of ecosystem services. The consequences of releasing untreated or inadequately treated wastewater have adverse repercussions on water quality and its availability for users downstream and also on economic activities.

Controlling and regulating various wastewater flows is the ultimate goal of wastewater management. Improved wastewater treatment, the increase in water reuse and the recovery of useful by-products support the transition to a circular economy by helping reduce water withdrawals, the loss of resources in production systems and economic activities (WHO, 2016). In Kenya, management of wastewater has not been adequately addressed by the government, political and social leaders (Kaluli *et al.*, 2011). Neglecting wastewater can have several adverse impacts on the sustainability of water supplies, public health, economic growth and the environment.

Wastewater treatment is a menace that has plagued developing countries affecting their surface waters as the discharge of inadequately treated wastewater has resulted in the degradation of ecosystems (Pavithra and Hina, 2016). The main goal of wastewater treatment is to allow domestic and industrial wastewater to be disposed without danger to public health or degradation of the natural environment. Thus, efficiently treated wastewater is the solution to the twin problem of water scarcity and wastewater disposal (Malik *et al.*, 2015).

University of Eldoret wastewater undergoes biological treatment in a series of four stabilization ponds. The treatment plant was designed to serve a population of 600 persons but the current population is over 15,000 persons. The treatment plant has a design capacity of 16210 m^3/day as per University of Eldoret public health department records. The sludge removal is long overdue and this has affected the operational and design efficiency of the wastewater treatment plant. As a result, the sewage treatment plant is overwhelmed by the high volume of influent and the excessive sludge. Release of untreated or partially treated wastewater to the environment degrade the receiving adjacent local aquatic ecosystems hence affecting their biota. The conditions and standards of the University of Eldoret effluent at the time of release to the environment is of great concern. There is a dearth of information on water quality indicator parameters of the University of Eldoret treatment plant especially heavy metals probably due to the high costs of analysis of these elements. The absence of such studies presents a gap in vital scientific information, considering that University of Eldoret wastewater treatment plant discharges its effluent in Marura wetland and river Chepkoilel. Marura wetland is an important wetland to the community and the waters of river Chepkoilel are used to grow crops that are consumed far and wide. Also, the waters are used for domestic purpose downstream.

METHODS

Study Area

The study was carried out at the University of Eldoret located in Uasin Gishu County, about 9 km north east of Eldoret town (Figure 1). Uasin Gishu County is located in mid-western Kenya, between 34°55'33" and 36°38'58"E and between 0°2'44"S and 0°55'56"N.

Wastewater Sampling

Sampling of wastewater was carried out at the University of Eldoret wastewater sewage treatment plant. The sampling points were the inlet (influent) of the first stabilization pond (anaerobic pond) and outlet (effluent) of the last stabilization pond (maturation pond). Samples were collected weekly from October to December 2018. At each sampling point, wastewater was sampled in triplicates. Water indicator parameters were analysed using standard methods according to (APHA, 2005). Physicochemical parameters that were analysed included temperature, pH, total dissolved solids and conductivity, which were determined in-situ using a multi tester digital pH meter (Model, H19811-5). Dissolved oxygen was measured using a dissolved oxygen meter and turbidity was measured using colorimeter. BOD_5 was determined as the difference between the oxygen concentrations of an appropriately diluted sample before and after incubation for 5 days at 20 ± 1° C while chemical oxygen demand was determined using micro digestion method (APHA, 2005).

Bacteriological Analysis

Aseptic techniques were employed in all bacterial analysis. Serial dilution was carried out and 1ml of the diluted sample inoculated on sterile media using pour plate method. MacConkey agar was used to culture feacal coliforms and Bile esculine azide agar was used for feacal streptococci. The number of colonies per 1ml was calculated as follows

$$\text{Cfu/ml} = \frac{\text{No. of colonies x dilution factor}}{\text{Volume plated (ml)}}$$

Nutrient Analysis

Phosphates in wastewater were determined by ammonium molybdate method. UV-Vis spectrophotometer (Model DU 720 Wagtech) was used to measure the absorbance of the samples at a wavelength set at 650 nm. Nitrates in wastewater samples were determined by brucine method. The UV-Vis spectrophotometer was used to measure the absorbance of the samples at a wavelength set at 420 nm.

Heavy Metal Analysis

The wastewater samples were digested using nitric acid digestion method (APHA, 2005). All the reagents used were of analytical grade and all the vessels were prepared according to procedures outlined in APHA (2005) to avoid external contributions of heavy metals. Wastewater samples were analyzed for heavy metals using atomic absorption spectrophotometer (Model, varian spectra 200). Quality was ensured by calibration of instrument using stock solutions. Sample blanks and calibration standards were included with every 10 samples for quality control.

Data Analysis

The reduction efficiency for water indicator parameters was calculated as follows;

$$\text{Reduction efficiency } (E_r) = \frac{\text{Influent concentration} - \text{effluent concentration}}{\text{Influent concentration}} X\ 100$$

Compliance index for various parameters was calculated to determine whether the effluent discharged from the wastewater treatment plant was compliant to the NEMA (Kenya) standards for effluent discharge to the environment. This is a statistical tool that shows at a glance the efficiency of a wastewater treatment plant. If the calculated compliance index value is less than 1 (<1) it indicates that the discharged effluent are compliant to the set standards, while a compliance index value of greater than 1 (>1) implies non-compliance.

Compliance index was computed as follows;

$$\text{Compliance index} = \frac{\text{Effluent concentration}}{\text{Maximum allowable value}}$$

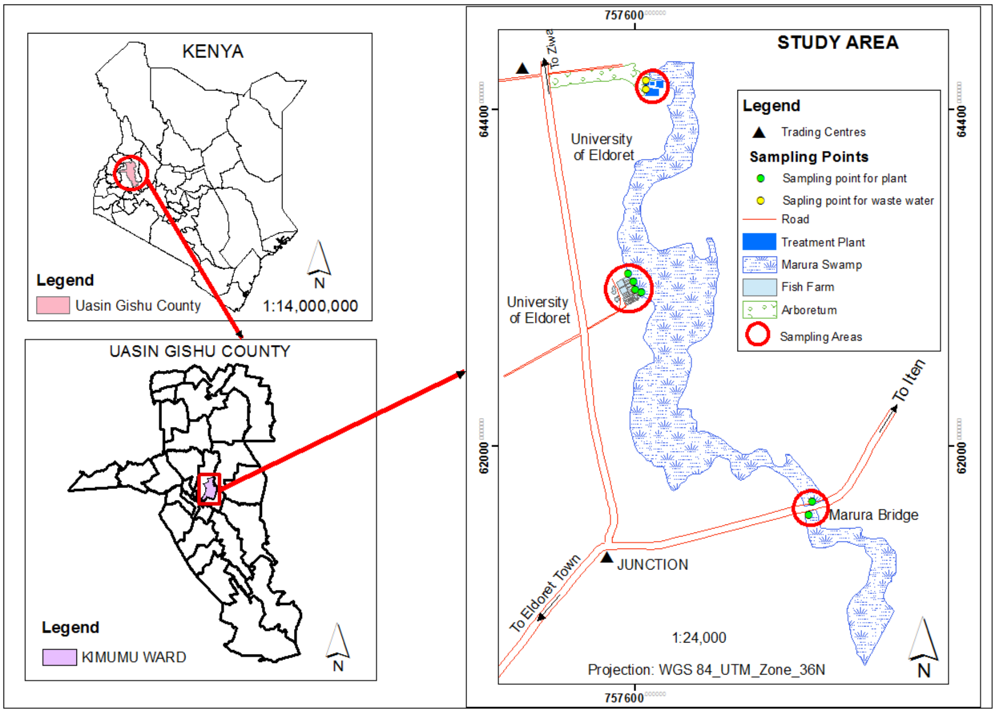

Figure 1: Location of University of Eldoret Wastewater Treatment Plant.

RESULTS AND DISCUSSION

Physicochemical Parameters

Temperature

The lowest influent temperature was 20.23˚C while the lowest effluent temperature was 18.4˚C. Highest influent temperature was 25.33˚C and the highest effluent temperature was 19.97˚C (Table 1). The temperature recorded throughout the sampling period was within the National Environmental Management Authority (NEMA) standards (±3 ambient temperature) hence compliant to Kenya standards. The temperature recorded at the inlet was higher than at the outlet. This could be attributed to exothermic reactions that takes place in the wastewater due to the presence of various dissolved organic and inorganic matter. Temperature is an essential climatic factor that controls the rate of chemical reactions (Ansari *et al.*, 2011). Higher temperature leads to low dissolved oxygen, promotes corrosion and increases solubility of other pollutants. The abundance, diversity and distribution of aquatic biota changes in relation to temperature variations in aquatic environments.

Turbidity

The mean turbidity for the influent ranged from 372.33 to 599 FAU while the effluent mean ranged from 126.33 to 188 FAU. The mean levels of effluent were lower than the influent. The highest reduction efficiency was 77.40% (Table 1). This could be ascribed to the process of sedimentation which takes place as wastewater moves from anaerobic pond to the subsequent ponds and the utilization of some of the organic and inorganic materials by macrophytes, algae and microbes in the wastewater hence leading to the reduction of turbidity in the effluent.

Table 1: Physicochemical Characteristics of Wastewater from University of Eldoret Sewage Treatment Plant

Parameter	**Influent range**		**Effluent range**		**Reduction efficiency**	**NEMA standards for effluent disposal to environment**	**Compliance index**
	Lowest recorded Mean	Highest recorded mean	Lowest recorded Mean	Highest recorded Mean	Highest recorded % E_r		Remarks
Temperature °C	20.23	25.33	18.4	19.97		Ambient Temperature ±3	Compliant
DO mg/l	0.44	1.75	3.03	5.29	-85.76	Not provided	
pH	6.83	8.30	6.87	8.5		6.5 - 8.5	Compliant
TDS mg/l	360	780	150	230	70.51	1200	Compliant
Conductivity µS/cm	750	1576.67	320	490	68.92	Not provided	
Turbidity FAU	372.33	599	126.33	188	77.40	Not provided	
BOD mg/l	432	1396	32	58	96.61	30	Not compliant
COD mg/l	1204	2654	116	156	95.29	50	Not compliant

(-) increase

(E_r) reduction efficiency

Dissolved Oxygen

The mean DO for the influent ranged from 0.44 to 1.75 mg/l. The effluent mean DO ranged from 3.03 to 5.29 mg/l. There was a general increase in DO in the effluent compared to the influent with the highest increase recorded as 85.76% (Table 1). This is expected especially if the degradation of organic matter by the bacteria takes place leading to reduction in BOD and COD which results in reduced DO consumption. Dissolved oxygen is vital for any aerobic biochemical action to take place, its levels are thus indicators of biochemical action. Reduced levels of DO in water impair metabolic reactions in aquatic organism. Increase in DO in the effluent could also be attributed to the presence of algae and floating macrophytes in the facultative and maturation ponds. These plants are photoautotrophs that utilize carbon dioxide in the presence of sunlight to release oxygen. Also, when wind agitates the surface of the pond, more oxygen dissolves in the wastewater through the water-air interface.

Oxygen is a key element in the biochemical transformation of organic matter. Dissolved Oxygen is indispensable for aquatic life. A DO range of 4 -11 mg/l is essential for the survival of aquatic organisms (Jagai *et al.*, 2015). Release of effluent with low DO lead to degraded water quality altering the diversity and abundance of the aquatic biota (Akunga *et al*., 2014; Orwa *et al.,* 2014).

pH

The mean pH for the influent ranged from 6.83 to 8.30. The effluent mean pH ranged from 6.87 to 8.5 (Table 1). There was a general increase in pH in the effluent compared to the influent. This may be as a result the amount of carbon dioxide used by algae in photosynthesis. Removing carbon dioxide in water reduces the acidity in water subsequently raising the pH (Williard & Roger, 2013). The high pH values may also be attributed to biochemical and chemical reactions, such as reactions of carbonate and bicarbonate ions which provide carbon dioxide for the microbes and macrophytes leaving an excess of hydroxyl ions (Ansari *et al.*, 2011). The optimum pH level for microbial activities is from 6.0 - 9.0. Outside this range, metabolic activities become impaired and can lead to declines in microorganisms. Further, pH controls nutrients uptake and biochemical reactions taking place in biota. Low pH levels accelerate the release of metals from rocks or from sediments in the stream which adversely affect aquatic organisms. Low pH irritates fish and reduces the survival of their juvenile stages and also affects amphibians (Ansari *et al.*, 2011). All the values of pH recorded within the sampling period were within the NEMA standards for effluent disposal to aquatic environment (non-marine) of 6.5 to 8.5.

Total Dissolved Solids

The influent means ranged from 360 to 780 mg/l while the effluent means ranged from 150 to 230 mg/l. The levels of TDS recorded throughout the sampling period were within the **N**EMA standards for effluent disposal to environment which is 1200 mg/l. The highest reduction efficiency was 70.51% (Table 1). The reduced TDS level in the effluent may be due to biological utilization of some of the dissolved solids by microbes, algae and macrophytes in the wastewater treatment plant. Also, some dissolved solids are chemically reactive in wastewater and hence can result in reduction of TDS. Discharge of effluent from wastewater treatment plants that have high levels of TDS can increase the amount of dissolved solids in aquatic ecosystems. Variations in the amounts of TDS can be detrimental to aquatic life as important processes such as osmosis and diffusion can be impaired. High levels of TDS in effluent may interfere with extraction of water by flora and fauna in effluent receiving ecosystem.

Conductivity

The influent and effluent mean ranged from 750 to 1576.67 µS/cm and from 320 to 490 µS/cm respectively. Generally, there was a reduction in the conductivity levels in the effluent compared to the influent. The highest reduction efficiency was 68.92% (Table 1). High conductivity in the influent indicate relatively higher concentrations of dissolved salt compared to the levels in the effluent. This may be attributed to the utilization of some essential salts by algae and macrophytes in the facultative and maturation ponds through root absorption.

Biochemical Oxygen Demand

The mean BOD for the influent ranged from 432 to 1396 mg/l while the effluent mean ranged from 32 to 58 mg/l (Table 1). The levels of BOD recorded throughout the sampling period were above the NEMA standards for effluent disposal to the environment of 30 mg/l. This is anticipated due to high organic matter in the raw wastewater. This is an indication of a high degree of organic pollution in the wastewater. The high values of BOD_5 in the effluent can be imputed to the overloading of the wastewater treatment plant. Also, the over accumulated sludge might have negatively affected the potential of anaerobic, aerobic and facultative bacteria to degrade the organic matter.

The high BOD_5 recorded in the effluent (58 mg/l) may lead to high rate of consumption of DO in wastewater which deplete the supply of oxygen in the water needed by aquatic life. Release of effluent with high BOD can lead to creation of anoxia conditions in receiving water body leading to death of aquatic organisms, anaerobiosis, odors and overall degradation of water quality. It also reduces species diversity in these ecosystems (Naidoo and Olaniran, 2013).

The highest recorded reduction efficiency was 96.61%. This may be as a result of biochemical oxidation brought about by microorganisms and macrophytes which utilize the polluting organic substances as sources of carbon, while utilizing atmospheric oxygen dissolved in water for respiration.

Chemical Oxygen Demand

The influent COD mean ranged from 1204 - 2654 mg/l while the effluent mean ranged from 116 to 156 mg/l (Table 1). The levels of COD obtained throughout the sampling period were above the NEMA standards for discharge into the environment from the outlet which is 50 mg/l. The high COD may be ascribed to the overloading of the treatment plant and the effect of over accumulated sludge which affects the operational and design efficiency of the wastewater treatment plant. The effluent values were lower than the influent values pointing out that the quality of the wastewater had improved although it was not compliant to the Kenya standards. The highest recorded reduction efficiency was 95.29%. COD is an oxygen-demanding waste hence release of effluent with high levels can be devastating to receiving aquatic ecosystem. It may upset oxygen balance of these surface waters resulting in hypoxia conditions (Jagai *et al.,* 2015).

Bacteriological Parameter

The influent mean for total coliforms ranged from 65783 to 83457 cfu/100 ml while the effluent ranged from 42180 to 62760 cfu/100 ml. The highest recorded reduction efficiency was 35.88% (Table 2). The levels of total coliforms recorded throughout the sampling period were above the NEMA standards for effluent disposal to environment which is 30 cfu/100 ml. Feacal coliforms for the influent ranged from 57083 to 73367 cfu/100 ml. The effluent cfu ranged from 28337 to 50043 cfu/100 ml. There was a general decrease in cfu in the effluent compared to the influent. The highest recorded reduction efficiency was 51.31% (Table 2).

The feacal streptococcus influent mean ranged from 36473 to 47243 cfu/100 ml while the lowest effluent mean ranged from 13320 to 30733 cfu/100 ml. The highest recorded reduction efficiency was 63.48% (Table 2). All the values of cfu recorded within the sampling period were above the NEMA standards for effluent disposal to the environment of 30 cfu/100 ml. The decrease in coliforms in the effluent is credited to bacteria die-off due to exposure to ultra violet light. UV radiation is lethal to all types of microbes due to its short wavelength and high energy. Lower levels of coliforms in the effluent may also be attributed to high levels of algae in facultative and maturation ponds. Algae is known for bactericidal potential and hence reduces the propagation of pathogenic bacteria.

Table 2: Bacteriological and Nutrients Characteristics of Wastewater from University of Eldoret Wastewater Treatment Plant

Parameter	**Influent range**		**Effluent range**		**% Reduction efficiency**	**NEMA standards for effluent disposal to environment**	**Compliance index**
	Lowest recorded Mean	**Highest recorded Mean**	**Lowest recorded Mean**	**Highest recorded Mean**	**Highest recorded % E_r**		**Remarks**
Total coliforms cfu/100ml	65783	83457	42180	62760	35.88	30	Not compliant
Feacal coliforms cfu/100ml	57083	73367	28337	50043	51.31	30	Not compliant
Feacal streptococcus cfu/100ml	36473	47243	13320	30733	63.48	30	Not compliant
Phosphates mg/l	4.53	4.98	3.0	4.5	35.76	2 guideline value	
Nitrates mg/l	3.95	17.03	1.47	6.17	81.77	2 guideline value	

(E_r) reduction efficiency

Phosphates

The mean phosphate for the influent ranged from 4.53 mg/l to 4.98 mg/l whereas mean for the effluent ranged from 3.00 mg/l to 4.50 mg/l. The highest recorded reduction efficiency was 35.76% (Table 2). The levels of phosphates were generally lower in the effluent compared to the influent. The reduction of phosphates in the effluent may be attributed to utilization of dissolved phosphates by various living organisms including bacteria, algae, fungi and macrophytes. Phosphates uptake by plants is dependent in part on microbial activity, which converts insoluble forms of phosphorus into soluble forms that are available to plants. Phosphorus is a macronutrient that is essential for the growth and development of flora as it is one of the key components of several metabolic and structural compounds in plant tissues. Phosphates play a critical role in the synthesis of nucleic acids, protoplasm and chlorophylls and is the backbone for ATP. It is usually the limiting factor for most living organisms in the ecosystems. NEMA does not provide specific value for phosphates discharge to the environment.

Nitrates

The level of nitrates in the influent ranged from 3.95 to17.03 mg/l while effluent mean ranged from 1.47 to 6.17 mg/l. The highest reduction efficiency was 81.77% (Table 2). High levels of nitrates in the influent may be as a result of high levels of nitrogenous compounds such as proteins, amino acids and ammonium. Low levels of nitrates in the effluent could be ascribed to the nitrates removal by bacteria, algae and macrophytes as they utilize nitrates for their growth and development. NEMA does not provide specific value for nitrates discharge to the environment.

Cadmium

Means for cadmium in the influent ranged from 0.044 to 0.097 mg/l. The effluent mean ranged from 0.088 to 0.109 mg/l (Table 3). All the means recorded throughout the sampling period were above the NEMA standards for effluent discharge to the environment which is 0.01 mg/l hence were not compliant to the Kenyan standards. The highest recorded increase was 56.86%. The increase in the amount of cadmium in the effluent is attributed to the over accumulated sludge in the stabilization ponds especially in the anaerobic ponds. Release of high levels of cadmium to the ecosystem can have detrimental effects on the biodiversity. Cadmium produces oxidative stress by releasing free radicals and reactive oxygen species which can cause death of organisms by damaging membrane lipids, proteins, pigments and nucleic acids (Al-Ubaidy *et al.,* 2015). Cadmium is carcinogenic, reproductive toxicant and an endocrine disruptor (Dubé and Cyr, 2013).

Copper

The mean for copper in the influent ranged from 0.026 to 0.728 mg/l whilst the effluent mean ranged from 0.029 to 0.741 mg/l. All the means recorded throughout the sampling period were within the NEMA standards for effluent discharge to the environment which is 1 mg/l. The highest recorded increase was 19.76% (Table 3). The increase in the amount of copper in the effluent may be due to the excessive sludge in the stabilization ponds especially in the anaerobic ponds. Copper discharged to wastewater is concentrated in sludge during treatment. Copper concentration of as low as 0.39 mg/l may be fatal to pond invertebrates and other aquatic organisms (Anu *et al.,* 2016).

Nickel

The mean levels of nickel in the influent ranged from 0.005 to 0.170 mg/l. The mean for the effluent ranged from 0.040 to 0.208 mg/l. The levels of nickel obtained throughout the sampling period in the effluent were within the NEMA standards for discharge into the environment which is 0.3 mg/l. The highest recorded increase was 87.5% (Table 3). The increase in the amount of nickel in the effluent may be due to the over accumulated sludge in the stabilization ponds. Possible sources of nickel in the wastewater include nickel-plated taps, nickel-steel alloy cookware, shampoos and detergents and hence can be present in grey water (National Toxicology Program, 2016). Nickel is important in the growth and development of some plants and microbes that have enzymes with nickel as an active site (Sydor *et al*., 2013).

Cobalt
Cobalt influent mean ranged from 0.016 to 0.184 mg/l. The effluent mean ranged from 0.006 to 0.205 mg/l. The levels of cobalt were higher in the effluent compared to the influent. The highest recorded increase was 44.07% (Table 3). This can be credited to possible accumulation of cobalt in the over accumulated sludge and in wastewater pathways within the treatment plant.

Table 3: Heavy Metal Concentrations in Wastewater from University of Eldoret Wastewater Treatment Plant

Parameter	**Influent range**		**Effluent range**		**% Reduction efficiency**	**NEMA standards for effluent disposal to environment**	**Compliance index**	**Compliance index**
	Lowest recorded Mean	Highest recorded mean	Lowest recorded Mean	Highest recorded Mean	Highest recorded % E_r			Remarks
Cadmium mg/l	0.044	0.097	0.088	0.109	-56.86	0.01	10.9	Not compliant
Copper mg/l	0.026	0.728	0.029	0.741	-19.76	1	0.741	Compliant
Nickel mg/l	0.005	0.170	0.040	0.208	-87.50	0.3	0.69	Compliant
Cobalt mg/l	0.016	0.184	0.006	0.205	-44.07	Not provided		
Manganese mg/l	0.485	0.724	0.556	1.01	-66.51	10	0.101	Compliant
Zinc mg/l	0.242	0.661	0.207	0.319	65.51	0.5	0.64	Compliant
Iron mg/l	0.421	3.0	0.377	0.956	68.33	10	0.10	Compliant
Lead mg/l	0.00	0.057	0.060	0.153	-62.74	0.01	15.3	Not compliant
Chromium mg/l	N.D	N.D	0.00	0.014		2	0.00	Compliant

N.D not detected
(-) increase
(E_r) reduction efficiency

Lead
Lead was detected once in the influent in the 1st week of sampling. The mean amount recorded was 0.057 mg/l. In the effluent, lead was detected twice during the 1st and the 2nd week of sampling. In the 1st week, the mean amount of lead recorded was 0.153 mg/l while in the 2nd week, the mean amount recorded was 0.060 mg/l. The amount recorded for the two weeks in the effluent was above the NEMA standards for effluent discharge to the environment which is 0.01 mg/l. The highest recorded increase was 62.74% (Table 3). Possible sources of lead may be from lead piping in water distribution systems, from lead paints and also from lead batteries (El-Khatib *et al.*, 2015). Currently, legislative measures to control use of leaded products such as fuel are being strictly enforced and this could have led to the low levels of lead in wastewater. Release of high levels of lead to the environment may have adverse effects on organisms as lead is known to be carcinogenic, mutagenic and teratogenic (Kristensen, 2015).

Chromium
Chromium was only detected once in the effluent in the 1st week of sampling. The mean amount recorded was 0.014 mg/l (Table 3). This level was below the NEMA standards for effluent discharge to the environment which is 2 mg/l. Chromium levels were below detection limit in most of the sampling period. This indicates that chromium pollution in the environment is minimal.

Manganese

The mean levels of influent ranged from 0.485 to 0.724 mg/l. The mean for the effluent ranged from 0.556 to 1.01 mg/l (Table 3). The levels of manganese obtained throughout the sampling period in the effluent were within the NEMA standards for discharge into the environment which is 10 mg/l. The highest recorded increase was 66.51%. The increase in the amount of manganese in the effluent is attributed to the over accumulated sludge in the stabilization ponds. Manganese is essential to organisms where it is utilized for growth and development. Manganese also functions in the oxygen-evolving complex of photosynthetic plants. It is a trace mineral for all known living organisms however, when in excess, it can have negative effect on biota *(*Erikson *et al., 2019).*

Zinc

The mean for the influent ranged from 0.242 to 0.661 mg/l. The mean for the effluent ranged from 0.207 to 0.319 mg/l. The levels of zinc obtained throughout the sampling period were within the NEMA standards for effluent disposal to the environment of 0.5 mg/l. Zinc mean value in the influent were higher than in the effluent. The highest recorded reduction efficiency was 65.51% (Table 3). Reduction of zinc in the effluent may be ascribed to the utilization of zinc by microorganism and macrophytes which require it for their growth and development. It is an essential element that catalyzes enzyme activity, contributes to protein structure and regulates gene expression. The reductions of zinc in the effluent could also be due sedimentation and precipitation processes.

Iron

The mean for the influent ranged from 0.421 to 3.0 mg/l. The mean for the effluent ranged from 0.377 to 0.956 mg/l. The levels of iron obtained throughout the sampling period were within the NEMA standards for effluent disposal to the environment of 10 mg/l. The highest recorded reduction efficiency was 68.33% (Table 3). Iron is essential for organismal growth and development (Okam, 2017). Its reduction in the effluent may be attributed to the utilization by microbes, algae and macrophytes. Some amounts of iron could have also been adsorbed in the sludge and on the wastewater pathways.

CONCLUSION

University of Eldoret wastewater treatment plant was not efficient in treatment of the wastewater as indicated by the levels of some investigated parameters such as coliforms, BOD, COD, lead and cadmium which were not compliant to the Kenyan standards based on calculated compliance indices. There is need to upgraded the wastewater treatment plant in order to handle the increased population hence high influent volume. The routine maintenance practices should be carried out which should include desludging the system at appropriate time, an action that is long overdue. Recommendation is made for the effluent being discharge from the wastewater treatment plant to be monitored regularly to mitigate the degradation of the receiving aquatic ecosystem and to ensure compliance to Kenya set standards.

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