



ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES AND BACTERIOLOGICAL LOADS OF WASTE WATER EFFLUENT FROM OXIDATION POND AT WOLDIA UNIVERSITY, NORTH WOLLO, ETHIOPIA

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ABSTRACT

Article History

Received: 13 May 2019

Revised: 19 June 2019

Accepted: 30 July 2019

Published: 6 September 2019

Keywords

Wastewater

Effluent

Physico-chemical

Oxidation pond

Heavy metals.

Rivers are vital component of the biosphere that contains less than one percent of the world's fresh water which is being polluted by indiscriminate disposal of domestic and industrial waste sewerage. The purpose of this study was to analysis the level of heavy metals and physico-chemical characteristics of wastewater effluent from oxidation pond. Samples were collected per month starting from May 2018 up to July 2018. Three sampling ponds were selected purposefully among constructed 13 different size oxidation ponds and one site in waste receiver river. Samples were collected by triplicate in each sample sites and totally 12 sample sites were fixed. Some parameters like (pH, Temperature, Conductivity, and Turbidity) were measured in situ. ICP-OES used for analysis heavy metal. XLSTAT version 2014.5.03 was applied for analysis and interpreting the relationship of each water quality parameters using one way ANOVA and Pearson correlation. This study shows Conductivity, pH, were showed highly significance difference among oxidation ponds while temperature showed non-significance difference ($\alpha < 0.05$). Sodium and potassium were found dominantly in all oxidation ponds and showed highly significance difference among sampling sites. The mean concentrations of heavy metals in the various stages of waste water treatment pond is not more polluted based on the WHO and FAO guidelines for different purpose. In general this study revealed that the treated wastewater effluent from oxidation pond is not relevant for human and livestock drinking rather than useable for irrigation purpose.

Contribution/Originality: This study used to contributes in the existing literature to review environmental problem related with domestic, industrial and municipal waste management. This study shows limitation of wastewater treatment using oxidation pond. The primary contribution of this finding is to determine the quality of effluent wastewater to recommend better removal efficiency oxidation pond.

1. INTRODUCTION

Water is an essential component for life on Earth, which contains minerals extremely important in human nutrition and also water is an invaluable resource to man and living things, essential for the sustenance of life (Al Nahyan, 2012). Water is a universal solvent essential to man for various activities such as drinking, cooking, industrial, hydropower, agricultural processes, waste disposal and human recreation. Most wastes contain organic solids, trace heavy metals, salts, bacteria, viruses, other microorganisms and sediment. Well water can be polluted

by wastes from both natural and anthropogenic sources, causing variations in biological, and chemical and physical parameters (Isikwue *et al.*, 2011).

Municipal wastewater is mainly contained small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries.

Treatment plants reduce pollutants in waste water to a level nature can handle. Untreated industrial, universities, hospital and other municipal wastewater contains non-biodegradable organic matter, heavy metals and other toxicants that deteriorate the receiving stream. Due to the large palette of inputs in the sewers, it contains certain undesirable components, including organic, inorganic and toxic substances, large amounts of potentially toxic elements (cadmium, copper, chromium, nickel, lead, cadmium, zinc and mercury) as well as pathogenic or disease-causing micro-organisms (Cai *et al.*, 2007; Fytili and Zabaniotou, 2008; Üstün, 2009; Karagiannidis *et al.*, 2011).

Currently in most developing countries different waste source pollutants including domestic, organization (Universities, Hotels, Hospitals and Industries) all are released these wastes in to natural environment without good treatment. According to Ethiopian Minister of health annual report three forth of the health problems of the children in the country are communicable diseases due to polluted water and due to improper sanitation. Over 60% of communicable diseases in Ethiopia are due to poor environmental health condition arising from unsafe and inadequate water supply and poor protection of water supply from contamination and regular surveillance of water sources (WHO, 2010).

Woldia University is one of the third generation academic institutions in Ethiopia. There are different source of waste effluents from the university which are harmful for downstream communities. For instance, wastes released from student dormitory, different chemicals in laboratory, organic wastes from student cafe, and waste from construction raw material disposal and wastes in each office. All of these wastes directly released in to the prepared oxidation pond which is used as a treatment plant. The principal objective of wastewater treatment is generally to allow human and organizational effluents to be disposed of without danger to human health or unacceptable damage to the natural environment.

That was the reason why we initiated to conduct this research on evaluating the efficiency of the constructed oxidation pond by assessing toxicity level of heavy metals, physicochemical and bacteriological characteristics of effluent wastes water from Woldia University. The general objective of this study was to determine the level of heavy metals, physico-chemical and bacteriological characteristics of waste water effluent from oxidation pond in Woldia University.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

Woldia University is one of the third generation universities and it's located in Amara region, North Wollo, Ethiopia. It is located at 521 km from north of Addis Ababa Ethiopia. Geographically Woldia University is located between latitude and longitude of 11°50'N39°36'E/11.833°N39.600°E, respectively and the elevation 2112 meters above sea level. There are different oxidation ponds in the university as shown in Figure 1.



Figure-1. Waste treatment oxidation ponds of Woldia University.

2.2. Apparatus, Chemicals and Standard Solutions

Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) (ULTIMA 2, HORIBA scientific) was used to measure the concentration of heavy metals. Temperature and pH were determined using HQ40d multimeter (HACH LANGE, NV), turbidity also determined using turbidity meter (HACH2100AN) and electrical conductivity (Wagtech EC/TDS meter, W-30210).

Chemicals that were used in the analysis are analytical grades (69-72% HNO_3 , Assay (acidimetric) 35.38% HCl (Ltd-121001). Stock standard solutions of metals Zn (998 $\mu\text{g}/\text{ml}$), Ca (1002 $\mu\text{g}/\text{ml}$), K (1003 $\mu\text{g}/\text{ml}$), Hg (999 $\mu\text{g}/\text{ml}$), Cr (1002 $\mu\text{g}/\text{ml}$), Cu (1002 $\mu\text{g}/\text{ml}$), Cd (1002 $\mu\text{g}/\text{ml}$), and Na (998 $\mu\text{g}/\text{ml}$) were prepared for the preparation of calibration curves for the determination of metals in the samples using ICP-OES used.

2.3. Research Design

A cross sectional prospective study design was applied for water samples that were collect from each sampling sites and the main sampling sites were fixed at primary influent oxidation pond one, at secondary influent site pond two, at effluent site in final oxidation pond and the point of mixing outflow treated waste water with natural water course in the downstream river.

2.4. Sample Collection and Preparation of Waste Water

Water samples were filtered using a vacuum pump and 0.45 μm pore-size filter papers in order to separate particulate matter in each site. The filtered samples were then split into two portions: based on the procedure followed by [Mwakaboko et al. \(2014\)](#) the first portion of wastewater samples were digested by taking 100 mL into 250 mL conical flask into which 5 mL concentrated HNO_3 were added. Then on the hot plate it evaporated under open reflux condition while adding small portions of the acid. The flask contents were then cooled, filtered with whattman No 42, and dilute to 50ml with distilled water. Then labeled prepared samples of waste water were transported to Bahir Dar University Chemistry department laboratory for metal analysis using ICP-OES.

2.5. Data Collection and Analysis Methods

2.5.1. Physico-Chemical

According to the procedure followed by [Aregawi and Meareg \(2015\)](#) the temperature and pH of water samples were measured at each sampling in situ. The Turbidity and EC were also measured from the study site.

2.5.2. Heavy Metal Analysis by ICP-OES

Inductively coupled plasma-optical (or atomic) emission spectrometry (ICP-OES8000 or ICP-AES) is an analytical technique used for determination of trace metals. Working standard solutions of 10 mg/L concentration were prepared from the respective stock solution by dilution from which, standard working solutions of series concentrations were freshly prepared. The operating conditions of ICP-OES and emission wave length for each studied metal were different. Such as the emission wave length of Cd (226.5nm), Cu (327.4nm), Zn (213nm), etc.

2.5.3. Data Analysis and Management

The recorded data were analyzed using statically analysis software (XLSTAT version 2014.5.03) which used for interpreting the relationship of each water quality among sampling site. One way ANOVA used for assess the heavy metal, nutrient and physico chemical quality analysis among the four main sampling sites. Pearson correlation was also used to identify the relation between each element. Data distribution and variability were represented by figures using standardized coefficient.

3. RESULT AND DISCUSSION

3.1. Physico-Chemical Properties of Waste Water

Among the measured physico-chemical properties of effluent waste water conductivity and pH meter were showed significance difference among sampling sites as shown in [Table 1](#) whereas, Temperature and turbidity were showed similar in all treatment ponds. The difference and similarity of physico-chemical properties of effluent waste water due to have different oxidation process in each oxidation ponds. This study showed that some physico-chemical properties like Temp, conductivity and turbidity were different as compare with guidelines of [WHO \(2010\)](#) and [FAO \(1985\)](#). However, this result showed that Woldia University effluent waste water has no potential impact for using irrigation purpose.

Table-1. Mean difference of physic-chemical properties of wastewater sampled in oxidation ponds (used XLSTAT version 2014.5.03, P<0.05).

Sites	Temperature (°C) mean	pH mean	Conductivity (µS/cm) mean	Turbidity (NTU) mean
Pond 1	25.4	9.27	810	82
Pond 2	26.2	8.83	1240	33.33
Pond 3	23.7	8.17	1213	56.66
River	25.9	7.63	940	34.33
Sign (P value)	0.626	0.000	0.001	0.271
Compare with WHO (2008) for drinking water and FAO (1985) guidelines setting for irrigation purpose.				
WHO	<40	6.5 -8.5	750	5
FAO	25-30	6.0 -8.5	3000	----

Source: Authors field work and laboratory analysis result, 2018.

The presence of high alkalinity (pH) showed highly correlated with turbidity and conductivity as shown in [Table 2](#). This indicates when the temperature increase or decline there might be no impact on changing the pH of the water.

Table-2. Pearson correlation of physico-chemical properties of waste water in oxidation ponds (XLSTAT 2014.5.03).

Pearson correlation	Turbidity	Temp	pH	Conductivity
Turbidity	1			
Temp	0.379	1		
PH	0.038*	-0.123	1	-
Conductivity	-0.196	-0.263	-407*	1

*Correlation is significant at the 0.05 level (2-tailed).

The variability of each physico-chemical properties of effluent waste water were determined by standardized coefficient per respective study sites as shown in Figure 2. PH of effluent waste water showed highly fluctuate among sampling site and conductivity and turbidity were also less variability as compare with pH Figure 2. Temperature is the least variability as compare with other physico-chemical properties of waste water.

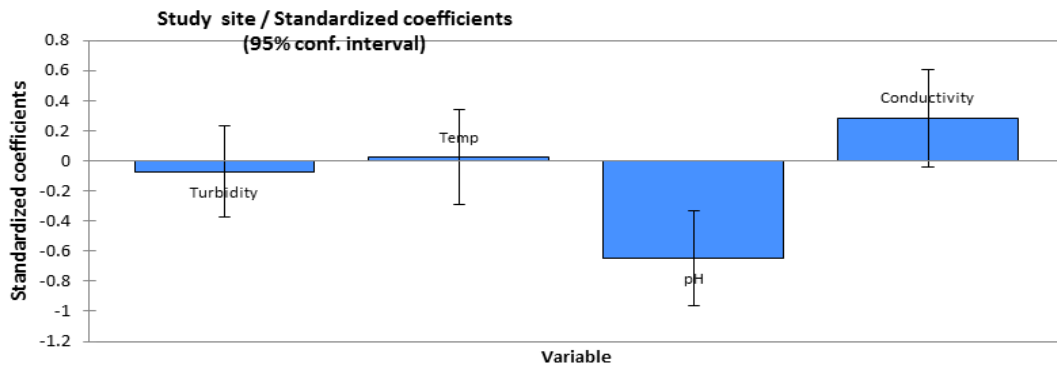


Figure-2. Variability of some physico-chemical properties of waste water in oxidation pond.

Source: Authors field work, 2018.

The mean values of temperature ranges from 23.7 to 25.9 °C which is found within the permissible limit in agreement WHO standards for all types of intended use and it also inline with the report of Bezuneh and Kebede (2015) and Kidu *et al.* (2015). There is also similar result reported by Flipos (2014) within the range of 30.5 to 23.2 °C. The mean measured value of pH was 9.27 which is higher than WHO and FAO permissible range for drinking purpose and irrigation (6.0 – 8.5), respectively. However the mean value of the measured pH after treatment (river) was 7.63 within the limit of WHO and FAO, the decrease in pH could be the availability of the metals ions in water would remain attached in substrate and complexes (Charles, 2013).

The increased EC value across the treatment pond may be due to the decreased water level caused by evaporation from high temperatures of the dry period since sampling was done during this period and it is in-line with the report of Mwakaboko *et al.* (2014). And also it might be the attached organic compounds in the water column decline from waste receiver ponds (1 and 2) to effluent ponds 3 and effluent waste receiver river. The mean turbidity value obtained from wastewater treatment pond was higher than WHO guidelines which suggest 5 NTU for drinking purpose. Similar results were reported by Fitsum *et al.* (2015); Kidu *et al.* (2015). This indicates that the entire wastewater is generally polluted and posing problems to aquatic lives and domestic use. The decreased turbidity value at the river may be associated with the amount of suspended materials and reduced organic matter might be decomposed and reduced due to the action of the anaerobic, facultative and maturation ponds (Flipos, 2014).

3.2. Concentration of Trace and Heavy Metals

The mean concentrations of Sodium and potassium were found dominantly in all oxidation ponds and showed highly significance difference among sampling sites. The result indicated that the presence of most heavy metals were very small concentrations and showed non-significance difference among sampling oxidation ponds as shown in Table 3.

Table-3. Mean concentrations of heavy metals (mg/L) and compare with FAO and WHO treatment pond.

Metals	P Value	Pond 1 (mg/L)	Pond 2 (mg/L)	Pond 3 (mg/L)	River (mg/L)	FAO mg/l	WHO mg/l
Na	0.000	94.040	75.533	75.503	25.673	900	200
K	0.000	43.997	34.300	36.930	5.2473	0.2	20
Ca	0.638	31.150	25.336	23.843	25.080	100	800
Cr	0.656	0.0190	0.0096	0.0160	0.0150	0.1	0.05
Zn	0.417	0.384	0.0440	0.0323	0.0416	2.0	0.2
Hg	0.441	0.023	ND	ND	ND	0.002	0.001
Cu	0.405	0.1043	0.0090	0.0083	0.0053	0.2	2
Cd	0.090	0.0026	0.0020	ND	ND	0.01	0.003

Source: Authors laboratory analysis result, 2018.

3.2.1. Sodium (Na) and Potassium (K)

The content of Na in the present study were ranged from 94.040 (pond1) to 25.6733 (river) mg/L with 24% overall reduction. In all the sampled sites the concentration of Na are lower than the permissible limit of WHO and FAO. In-line with this findings similar result were reported by *Abate et al. (2015)*; *Sandra (2013)* and *Bezuneh and Kebede (2015)*. The concentrations of K in all sampling sites except at the river are above the permissible limit set by WHO guidelines. This is may be the use of detergents and soaps for cleaning purposes from student's dormitory, cafeteria, etc.

Calcium (Ca) and Copper (Cu): In the present study, calcium content in mg/L was ranged from 31.150 (pond1) to 23.8433 (pond3) with positive reduction efficiency however the reduction is negative at the river, this may be related to weathering of Ca rich soil or cementing materials down the stream (*Fitsum et al., 2015*). The recorded values of Ca in all sites lie within the prescribed limit of WHO and FAO *Table 3*. Copper indicated no significant variation across the WWTP ($p > 0.05$) although the concentration reduced by 70.15% with levels dropping from 0.1043 (pond 1) to 0.0053 (river) mg/L, which was within the maximum permissible limits of WHO and FAO (*Hunachew and Getachew, 2011*; *Bezuneh and Kebede, 2015*; *Alsaffar et al., 2016*) for drinking and irrigation purpose respectively.

Zinc (Zn): The result showed that concentration of Zn in all wastewater sample sites except pond 1 was lower than the permissible limit set by FAO and WHO. This result is similar with the report of *Tadesse et al. (2018)*; *Hunachew and Getachew (2011)* and *Alsaffar et al. (2016)* for discharged to the environment.

Cadmium (Cd) and Mercury (Hg): The mean concentration of Cd and Hg was recorded as (0.0026mg/l) and (0.023mg/l) respectively at the raw waste water sample collected (pond1), while the mean concentration of Hg and Cd was not (found) detected at (pond 3 and river) collected from waste water treatment pond with 100% reduction. Heavy metals can also precipitate as metal sulfides (*Sandra, 2013*; *Mulu and Ayenew, 2015*).

Table-4. Pearson correlations in between some heavy metals sampled from oxidation pond (XLSTAT version 2014.5.03).

Pearson corr.	Na	K	Ca	Cr	Zn	Hg	Cu	Cd
Na	1							
K	0.992**	1						
Ca	0.189	0.200	1					
Cr	0.006	0.059	0.858**	1				
Zn	0.246	0.270	0.943**	0.896**	1			
Hg	0.245	0.271	0.937**	0.898**	0.999**	1		
Cu	0.272	0.297	0.939**	0.886**	0.998**	.999**	1	
Cd	0.520	0.445	-0.209	-0.443	-0.188	-0.217	-0.197	1

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

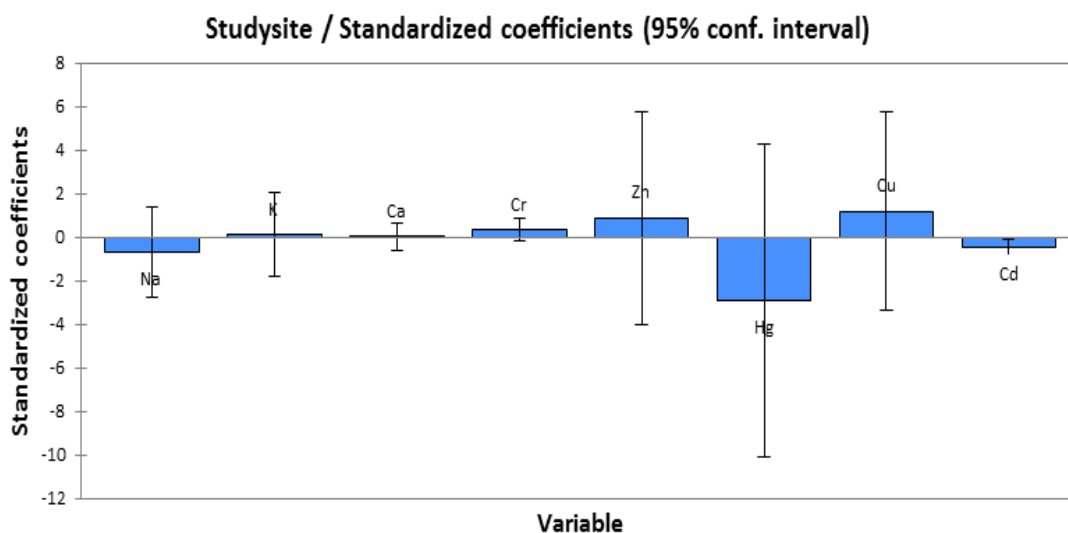


Figure 3. Heavy metal distribution and its variability in different sampling sites.

Source: Authors laboratory analysis result, 2018.

4. CONCLUSION AND RECOMMENDATION

Generally the results of the study showed that the waste receiver rivers in Woldia Town were polluted due to unsafe disposal of Woldia University. This might be could have negative impact on downstream community health and riverine ecology. Sewerage waste lines from the university and municipal garbage of the town that directly contact to the river and stream should be well treated before released in to the natural river course. The university and municipal administration and stakeholders should plan and implement a suitable waste disposal and treatment strategies to alleviate its river and stream water pollution problems. Woldia University waste treatment oxidation pond is not efficient to avoid toxic and pathogenic contamination. The current constructed oxidation pond have to be monitoring in day-to day and proper control mechanism are needed to improve the efficiency of the waste water treatment pond.

Funding: The authors greatly indebted to Woldia University for provision of funds for this study.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgement: The authors would like to express their gratitude to Dr. Dawit for his collaboration. Additional they would like to thankfully for all Woldia University Biology and Chemistry department laboratory technical for their contribution during lab analysis work.

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