Evaluation of Heavy Metals Concentrations in Produced Water from Selected Flow Stations in Niger Delta Region, Nigeria

Oghenevovwero Emmanuel Esi.[1*], Nelson Ofomaja[2], Peter Orisekpabor Odedede[3]

[1]*Department of Science laboratory Technology Delta State School of Marine Technology, Burutu, Delta State, Nigeria*
[2] *Department of Mechanical Engineering, Delta State School of Marine Technology, Burutu, Delta State, Nigeria*
[3]*Department of Industrial Safety and Environmental Technology, Petroleum Training Institute, Effurun, Nigeria*

***Abstract*:-Heavy metal concentrations in sampled produced water from seven selected flow stations in the Niger Delta region of Nigeria were investigated. Atomic Absorption Spectrometer (AAS) was used to determined heavy metals (Ca, Pb, Na, Mg, K, Mn, Fe, Zn, Ni, Cr, Cu and Cd) concentrations. A total of twenty one (21) representative samples of produced water from seven flow stations (3 each) were collected for the study. The heavy metal mean values are pH is 8.12, Na is 183.6 mg/l, Mg is 8.17 mg/l, Ca is 10.27 mg/l, K is 24.6, Mn is 0.003mg/l, Fe is 0.17mg/l, Zn is 0.323mg/l, Cu is 0.025mg/l, Cd is 0.013mg/l respectively, while Pb, Ni and Cr are Blow detectable limit (BDL) respectively. The heavy metals values where found to be slightly in compliance with both national and international standards. However, produced water should be adequately treatment before been discharge into the environment, to protect the health of the oil and gas worker and the residents of the study area.**

Key words: **Produced water, Heavy metal, Compliance, Concentration and Flow stations**.

I. INTRODUCTION

During oil and gas production, significant trapped water usually accompanied petroleum products to the surface of the earth from the reservoir rocks. This water is formation water that is naturally present in the reservoir rocks or injected water into the reservoir rocks by operator (Huishu Li, 2013). This water has been in contact with the hydrocarbon-bearing formation for years, and as such, it contains some of the physical and chemical characteristics of the formation and the hydrocarbon which are present in the reservoir rocks (Hardi *et al.,* 2019; Chikwe and Okwa 2016). It is called Produced water. These Produced water generally contain high level of pollutant such as suspended oil, salt content, potentially toxic and chemicals elements, heavy metals, insoluble and soluble organic matter and Naturally Occurring Radioactive Material (NORM) (Ayad, *et al., 2010;* Chikwe and Okwa 2016). Oil and gas facilities (flow stations) produce large volumes of contaminated wastewater (produced water) during oil and gas production. The heavy metals in produced water include zinc, lead, manganese, iron, barium, uranium, cadmium, chromium, strontium ,carbonate, bromide sulphate antimony, arsenic, bismuth, cerium, cobalt, copper, gallium, gold, mercury, nickel, silver, tin, vanadium if not properly treated before being discharged into the water bodies and farm land can poses significant threat to human life and the environment (Veil *et al., 2004;* Tiana, 2015).

Heavy metals are chemical elements which are identified as toxic and carcinogenic substances. They exist as positively-charged ions and can bind on to negatively charged organic molecules to form complexes by which impacting the human health and other living organism in environmental negatively (Hardi *et al.,* 2019). These heavy metals enter and accumulate in the human body through food chain and exposure of the human skin when they come in contact. Ingestion, inhalation and external exposure of heavy metals in concentrations higher than the world permissible limit in produced water can cause serious health hazard in human such as vascular blockages, early aging, abnormality of growth and development, damage of functional organ, stress, decreased sex drive, stuffiness of head, cancer, nervous system damage, gastrointestinal, genetic malfunction, kidneys diseases, damaging of the brain and death (Mehta and Saini, 2017; Tsuji and Karagatzides, 2001). Also, ecological health of the water bodies and the environment is threatened by the discharge of toxic compounds of produced water and the accumulation of these contaminants in these aquatic environments.

Several studies as been carried out by scientist on heavy metals evaluating in produced water and they concluded that the concentrations of heavy metals are higher than the world limit values (Erakhrumen, 2015; Isehunwa and Onovae 2011; Oboh *et al*., 2009). Hardi *et al., 20*19 studied showed that the produced water in Siak Regency is harmful to man as source of drinking water. Chikwe and Okwa 2016; Okoro 2010; Obunwo and Chukwudi, 2015) studies on heavy metals concentrations in produced water reveled that measured values arewithin the permissible limits set out by Nigeria's Department of Petroleum Resources (DPR) .

This study is thus aimed at evaluating heavy metals concentrations in produced water from some selected oil and gas flowstations in the Niger Delta, Nigeria and to show level of compliance by the oil and gas operator

Study Area

The study flow stations are located in Delta State which lies within latitude 5°18" N and 5°86" N and longitude 5°33"E and. 6°40 E", South-west of Niger Delta region of Nigeria (UNDP, 2006). It is one of the most significant onshore oil and gas production area in the Niger Delta with about 172 oil wells with 10 flow stations and 14 flare stack sites. The area is criss-cross with network of pipelines carrying oil or gas to the flow stations from the various oil and gas wells (UNDP, 2006; Avwiri, et al., 2007).

II. MATERIALS AND METHODS

Three (3) samples each of produced water were collected from the outlet lines of some selected hydrocarbon production flow stations in Niger Delta region of Nigeria. A total of twenty one (21) Samples were collected in chemically clean amber glass bottles. The glass bottles were rinsed with sample of produced water before being filled and properly covered with Teflon-lined lids in such a way as to completely protect all the produced water samples from external contamination at the sampling sites. The sampled produced water glass bottles containers were properly labelled for identification. Samples were transported in an ice chest cooler to the laboratory for analyses in view of determining detecting heavy metals in the sampled produced water using Atomic absorption spectroscopy (AAS).

III. RESULTS AND DISCUSSION

Table 1 showed the mean results obtained from the pH meter and the laboratory analysis concentrations of heavy metals in sampled produced water from the selected flow station in the Niger Delta Region and some world permissible limit e.g EU, 1998; EGASPIN, 2000; NESREA, 2010.

Table 1: Mean Results of pH and heavy metals (mg/l) in Produced Water

SN	CODE	Flow Stations	pH	Na	Mg	Ca	K	Mn	Fe	Zn	Cu	Cd
1	PWAF	AFIESERE	8.27	212.3	4.70	6.17	23.78	ND	0.037	0.043	0,011	0.010
2	PWOW	OWHE	8.31	196.3	9.26	6.32	27.85	ND	0.074	2.02	0.015	0.012
3	PWOT	OTOROGU	8.20	166.6	1.42	3.79	9.16	0.001	0.166	0.048	0.019	0.011
4	PWOG	OGINI	7.99	146.8	18.46	20.85	41.81	0.001	0.127	0.01	0.020	0.011
5	PWER	ERIEMU	8.32	277.9	3.56	8.64	18.40	0.002	0.180	0.086	0.033	0.018
6	PWEV	EVWRENI	8.13	212.7	2.69	7.31	16.61	0.007	0.212	0.038	0.032	0.018
7	PWOL	OLOMORO	7.59	72.5	17.1	18.79	34.59	0.006	0.230	0.018	0.031	0.014
Mean			8.12	183.6	8.17	10.27	24.6	0.003	0.17	0.323	0.025	0.013
World Standard			**6.5-8.5**	**200**		**75**		**0.05**	**1.0**	**1.0**	**1.5**	**0.003**

Table 2: Below Detectable Limit (BDL) Mean Results of heavy metals (mg/l) in Produced Water

SN	CODE	Flow Stations	Pb	Ni	Cr
1	PWAF	AFIESERE	BDL	BDL	BDL
2	PWOW	OWHE	BDL	BDL	BDL
3	PWOT	OTOROGU	BDL	BDL	BDL
4	PWOG	OGINI	BDL	BDL	BDL
5	PWER	ERIEMU	BDL	BDL	BDL
6	PWEV	EVWRENI	BDL	BDL	BDL
7	PWOL	OLOMORO	BDL	BDL	BDL
Mean			BDL	BDL	BDL
World Standard			0.01	0.02	0.03

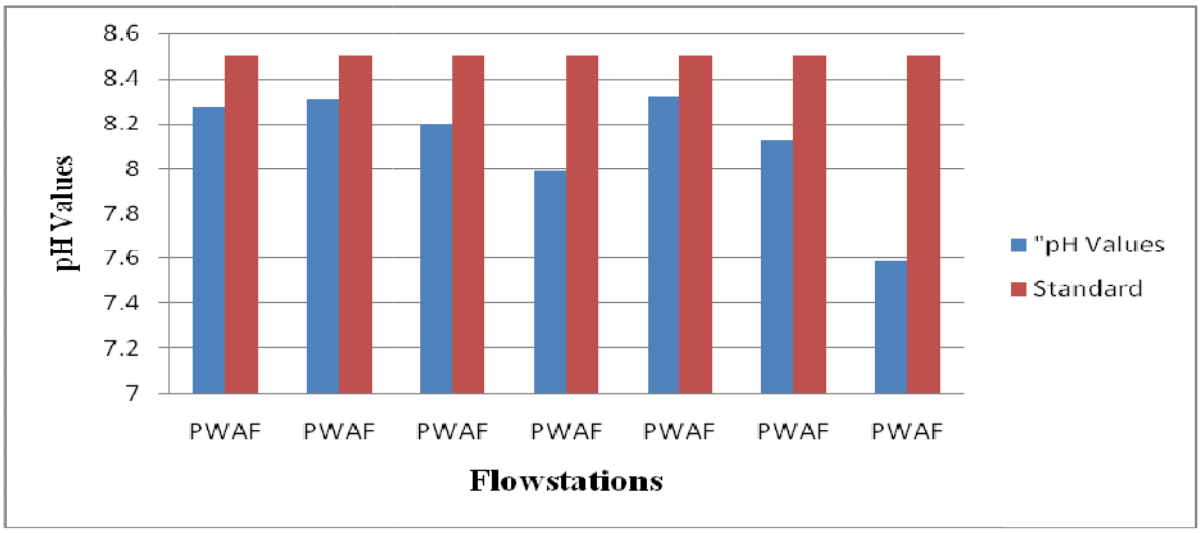

Fig.1: Bar chart showing comparison of PH values with standard.

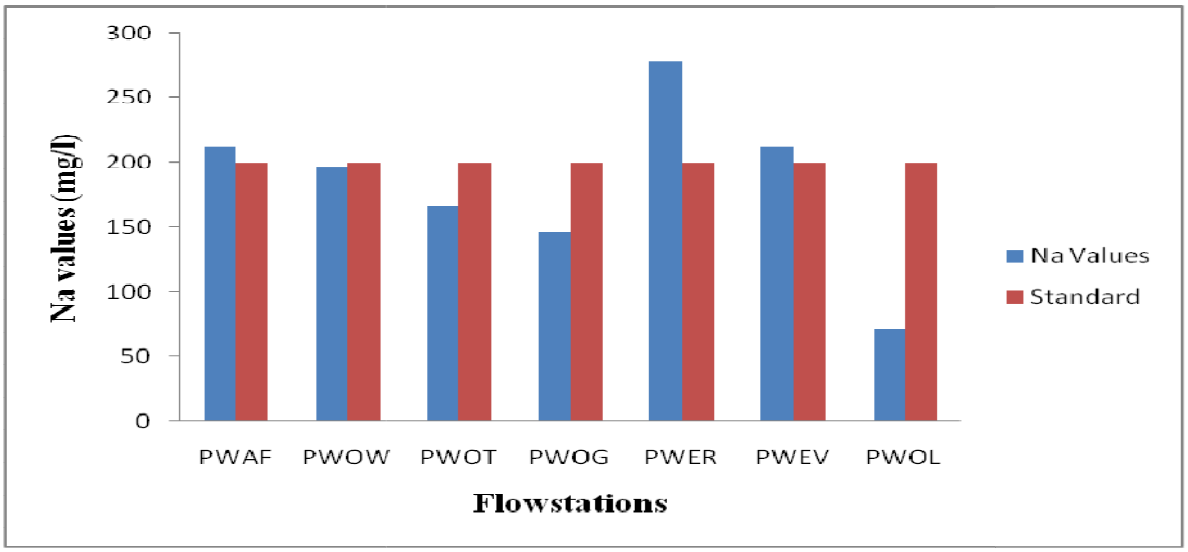

Fig.2: Bar chart showing comparison of Na values with standard.

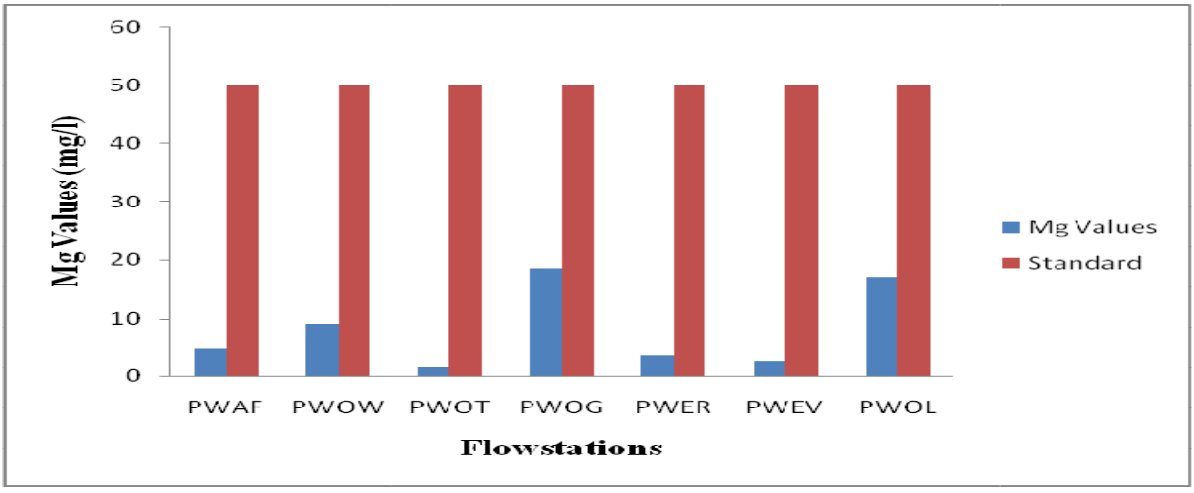

Fig. 3: Bar chart showing comparison of Mg values with standard.

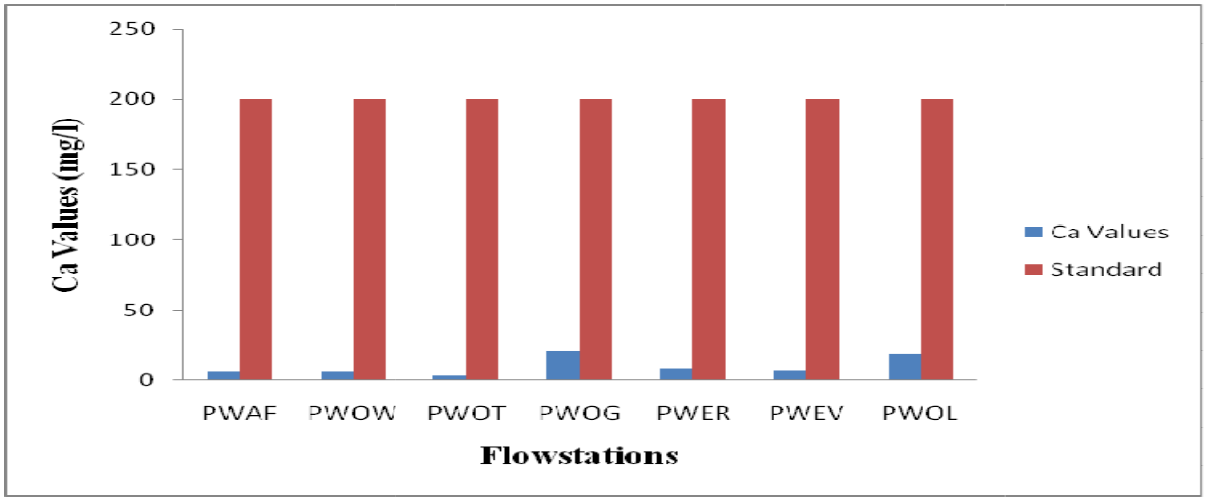

Fig. 4: Bar chart showing comparison of Ca values with standard

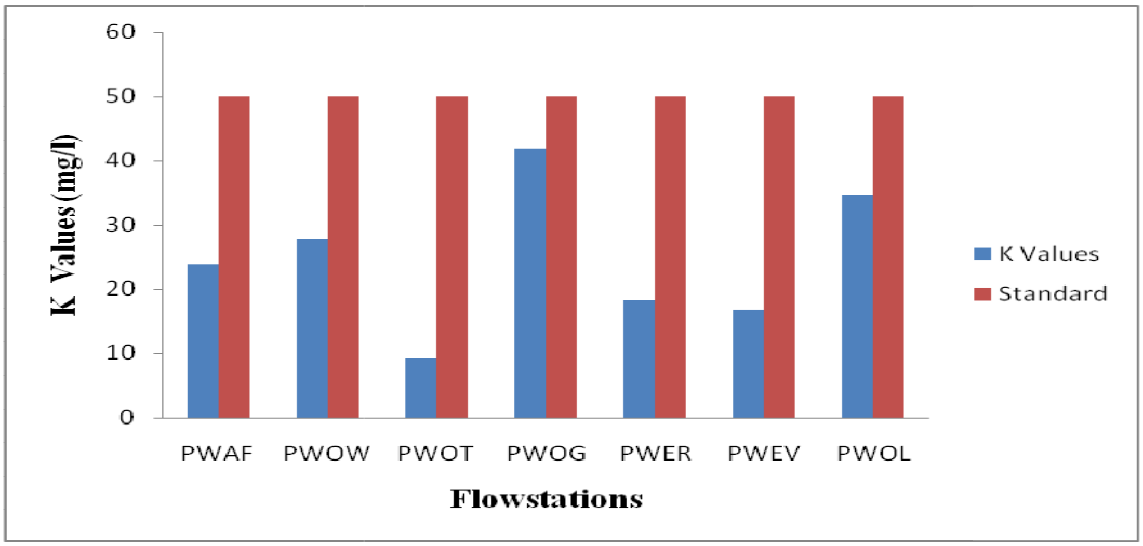

Fig. 5: Bar chart showing comparison of K values with standard

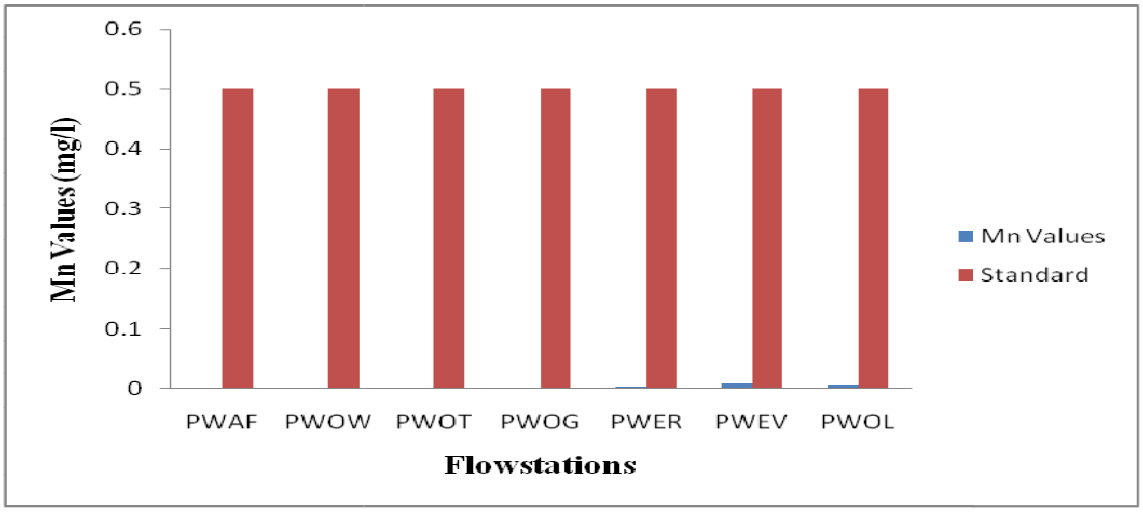

Fig. 6: Bar chart showing comparison of Mn values with standard

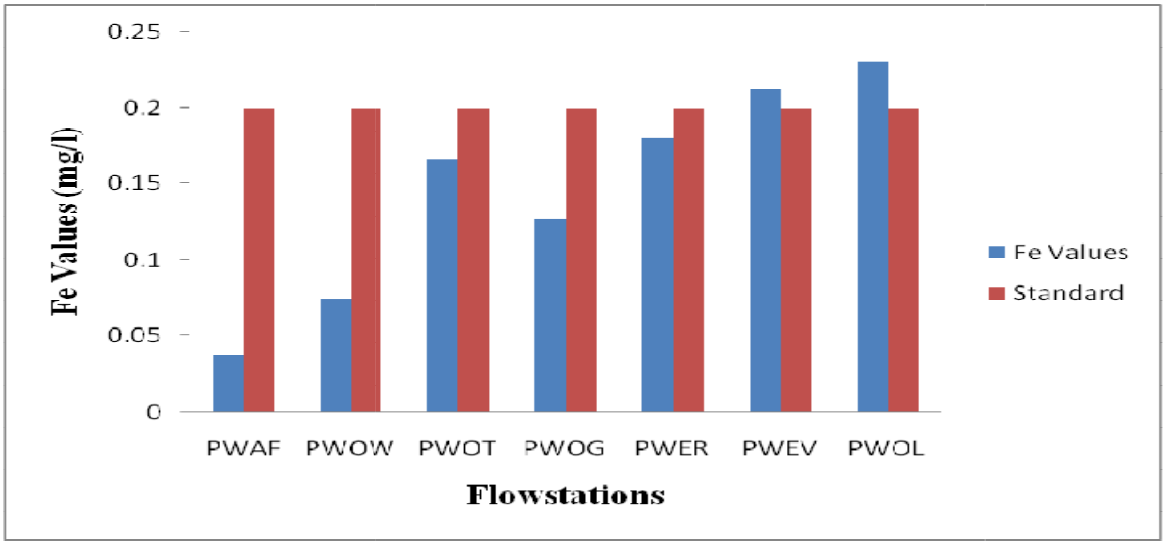

Fig. 7: Bar chart showing comparison of Fe values with standard

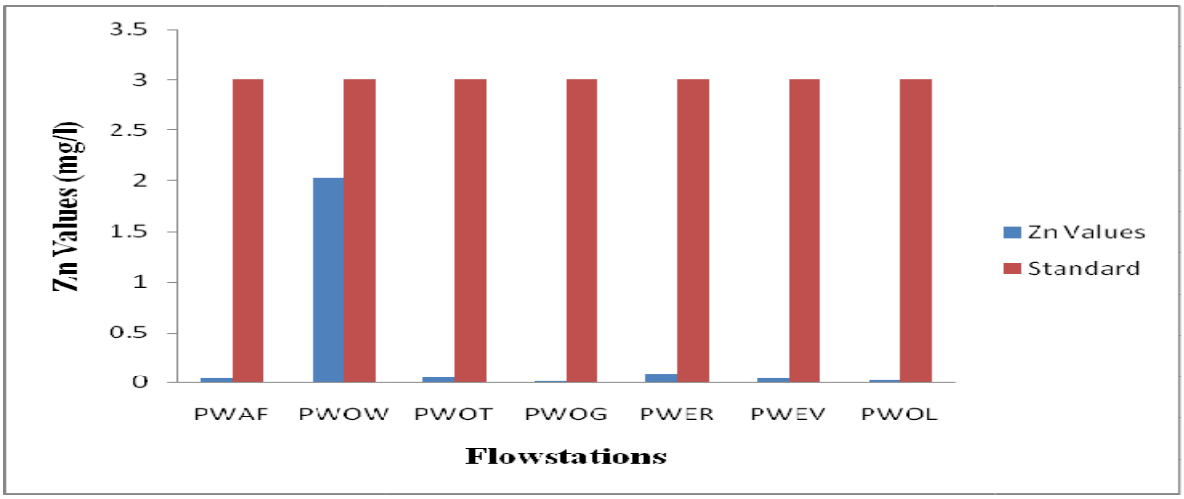

Fig. 8: Bar chart showing comparison of Zn values with standard

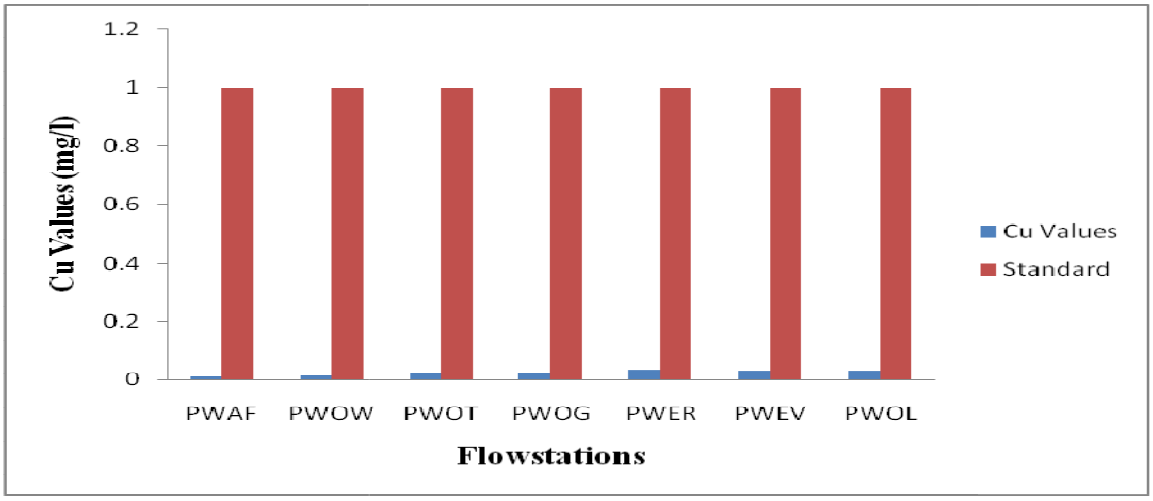

Fig. 9: Bar chart showing comparison of Cu values with standard

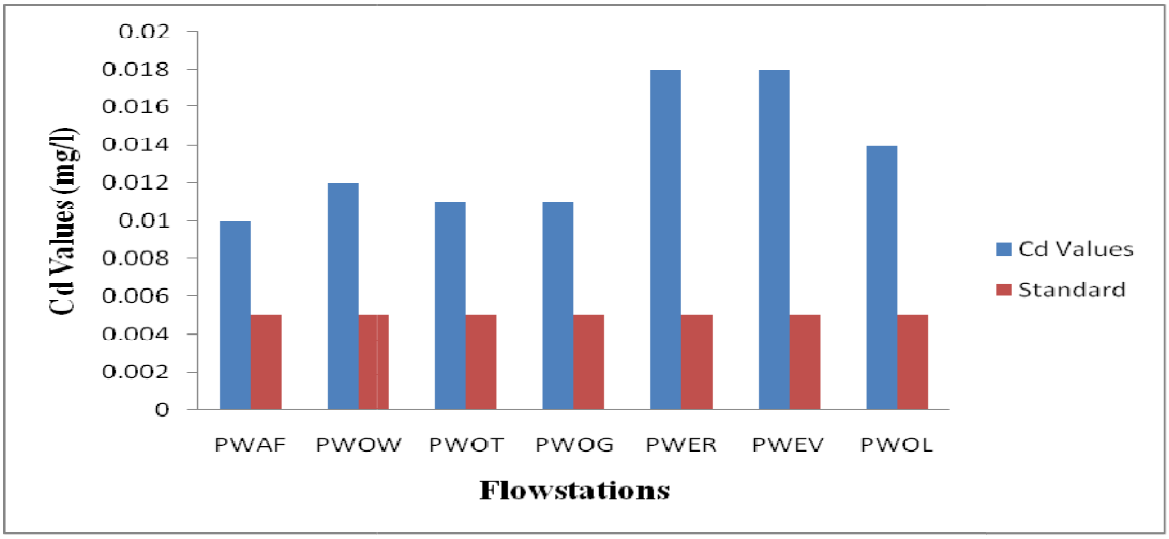

Fig. 10: Bar chart showing comparison of Cd values with standard

pH obtained values ranged from 7.59 to 8.32 with a mean value of 8.12, comparing the flow stations obtained values with EGASPIN, 2000 (Environmental Guideline and Standard for Petroleum Industries in Nigeria) standard the results fall within the world permissible maximum limits. The obtained values are also in agreement with previous work done the the Niger Delta Region of Nigeria Onojake *et al*., (2012) and Isehunwa and Onovae (2011). The obtained values for Sodium (Na) ranged from 72.5 mg/l at Olomoro flow station to 277.9mg/l at Eriemu flow station with average value of 183,6 mg/l. Comparing the obtained value of Sodium with standard of 200mg/l (EU, 1998), it shows that some flow stations like Owhe, Otorogu, Ogini and Olomoro flow stations obtained values fall within the allowable maximum permissible limit while Afiesere, Eriemu and Evwreni flow stations are higher than normal. This may be as a result of the type of chemical used in these flow stations. The obtained values for Mg ranged from 1.42 mg/l at Otorogu flow station to 18.46 mg/l at Ogini flow station with average value of 8.17 mg/l. The obtained values for Calcium (Ca) ranged from 7.31 mg/l at Evwreni flow station to 20.85 mg/l at Ogini flow station with average value of 10.27 mg/l. The obtained values for Potassium (K) ranged from 9.16 mg/l at Otorogu flow station to 41.81 mg/l at Eriemu flow station with average value of 24.6 mg/l.

The obtained values for Manganese (Mn), Iron (Fe), Zinc (Zn) and Copper (Cu) ranged from BDL mg/l, 0.037 mg/l, 0.010 mg/l and 0.011 mg/l respectively at Afiesere, Owhe and Ogini flow stations to 0.007 mg/l, 0.212 mg/l, 2.02 mg/l and 0.033 mg/l respectively at Evnremi, Owhe and Eriemu flow stations with average values of 0.003 mg/l, 0.170 mg/l, 0.323 mg/l and 0.025 mg/l respectively. Comparing the obtained values of Manganese (Mn), Iron (Fe), Zinc (Zn) and Copper (Cu) with standard (EGASPIN, 2000), it shows that all flow stations obtained values are below the allowable maximum permissible limit except Zinc (Zn) at Owhe flow station that is higher than standard. These obtained values are also in agreement with those reported in some other areas within the Niger Delta Region of Nigeria (Chikwe and Okwa, 2016; Erakhrumen, 2015; Onojake *et al*., 2012; and Isehunwa and Onovae 2011 and Oboh *et al*., 2009). The obtained values for Cadmium (Cd), ranged from 0.010 mg/l at Afiesere flow station to 0.018 mg/l at Eriemu and Evnremi flow stations with average value of 0.013 mg/l, while that of Pb, Ni, and Cr are below detectable limit (BDL) in all the flow stations produced water sampled as shown in table 2. However, (Oboh *et al*, 2009), reported the present of high levels of heavy metal in produced water in a Nigerian oil facility, the results of the study within these period showed slightly compliance with standards. Research as shown that the concentration of heavy metals in produced water has direct correlation with the age and geology of the rock formation of that area (Vitt *et al.*, 2003). Therefore, the heavy metals concentration level may be attribute to the geology of the rock formation and possible the drilling chemical used during operation.

IV. CONCLUSION

This study has shown that concentrations of heavy metal in produced water from some selected flow stations in the Niger Delta region are slightly in compliance with both national and international standards for discharge into the environment. However, produced water should be adequately treatment before been discharge into the environment. It is therefore recommended that adequately treatment produced water should be injection to oil reservoir to enhance oil recovery (EOR) in Niger Delta region oilfield. This is for now the best protecting and management global practice of produced water.

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