This was dosed at different concentrations, Every 0.5 ml of the 1ppt solution make up a 1ppm (part per million) of concentraion when added into the 500ml waste water sample. Varying concentrations were continually dosed until floccs were formed in the water samples. Floccs were produced at different concentrations of the Aluminium Chlorohydrate. Flocculents were later each added after the floccs had been formed in order to grow the floccs bigger so that they could settle at the bottom of the beaker. Clearer water remains at the top while the entire dirt settles at the bottom of the beaker. The seven water samples; influent, untreated effluent, and the five samples treated at different concentrations, were all diluted into the ratio of 1:10. A 10ml pipet was used to draw a 10ml treated sample, and the 10ml drawn sample was added into a 100ml volumetric flask. Demineralised water was added to the 10ml treated water sample to fill to the 100ml mark of the volumetric flask to dilute the sample into the ratio 1:10. The same dilution procedure was repeated to the other samples; the influent, the untreated effluent, and the treated effluent.

3.2 Nitrate Test

The test for nitrates was started by filling a 10ml glass sample vial, a nitrate reagent reagent; nitraver 5 Powder; a cadmium, Gentisic acid based product, was added into the 10ml sample vial. The vial was closed and shook vigorously till all the nitraver 5 powder was dissolved. A three minutes reaction took place between the nitrates concentrated water and the reagent. A colour change to yellowish brown was observed in the sample vial. The vial was then inserted into a sample slot in the DR3900 Spectrophotometer. A nitrate program was selected in the Spectrophotometer, another sample vial was filled with 10ml of the same diluted water sample but no reagent was added on the second sample vial. This was used as a blank to zero the photometer. After the photometer had been zeroed, the sample with nitraver 5 reagent was then inserted in the photometer and was run. The Spectrophotometer gave a reading of nitrate concentration in milligrams per Litre (mg/L or ppm). This reading was multiplied by ten due to the dilution factor of 1:10. The same was repeated for all the other samples.

3.3 Phosphates

The test for Phosphates was also conducted according to the above procedure. A 10ml sample vial was filled with the 1:10 ratio diluted water sample. Phosphate reagent; Phosphover 4 Powder this is a Potassium Molybdate, Potassium pyrophosphate based product; it was added to the sample vial with diluted water sample. The sample turned blue, and a four minute chemical reaction was allowed to take place to completion. An unreacted dilute solution was added in a separate sample vial to be used as a Blank to zero the Spectrophotometer. A phosphate program was then selected. The blank was inserted in the sample slot of the Spectrophotometer, the instrument was zeroed and the blank sample was taken out of the slot. The blue water sample with Phosphate reagent in the 10ml sample vial was, then inserted in the sample slot of the Spectrophotometer. Phosphate concentration was read in ppms. The reading that came was multiplied by 10 to accommodate the dilution factor.

3.4 Total Suspended Solids

A DR 3900 Spectrophotometer was used to analyse the Total suspended solids. A sample of deionised water was added in a 10ml Vial and inserted in a sample slot of the Photometer. A Total suspended solids program was selected. The deionised water was used to zero the instrument. A sample of the effluent waste water was then added in the 10ml sample vial and inserted in the Photometer. The instrument was then run; it gave the reading in milligrams per litres. The same procedure was repeated for the other samples. A sample was diluted into a 1:10 ratio by diluting 10ml of the sample in a 100ml Volumetric Flask. Deionised water was added to fill the flask. A 2ml Pipette was used to draw a 2ml Sample from the dilute sample. The 2 ml sample was added in a High range COD reagent, It is a Sulphuric based product that is being purchased in specialised test tubes. The same was repeated for the other samples. The tubes were tightly closed and vigorously shook. 2ml deionised water was also added in a separate test tube to be used as a Blank. The test tubes were inserted in the slots of a COD heater. The Samples were digested for two hours by heating at 150^0C. The digested samples were then allowed to cool down to an ambient temperature. The Blank sample was then inserted in a slot of the DR3900 Photometer. The COD High range program was selected, and the instrument was zeroed using the blank sample test tube. The water samples were read and the COD readings were multiplied by ten to accommodate the dilution factor.

4. Results and Discussion

The Three Coagulants; Aluminium Chloro hydrate, Ferric Chloride and Ferriflocc that were used as sources of flocculation in the abattoir waste water treatment experiment reacted differently from one another. A Poly amide polymer was later used. Ferriflocc were used in the treatment of the abattoir waste water while the interaction presented in Table 1 were observed between the abattoir waste water samples. Table 2 presents the various components of the raw effluent sample while what obtains in a treated sample is shown in Table 3.

Table 1: Effluent interactions with different reagents

Ferri Flocc (ppm)	Poly Amide Polymer	PH	Turbidity (NTU)	Phosphates (ppm)	Nitrates (ppm)	COD (ppm)	TSS (ppm)
0	40	6.89	668	372.45	111.2	2934	971
20	40	6.89	554.8	355.7	92.78	2644.6	811.2
40	40	6.89	442.6	339.4	74.36	2355.2	651.4
60	40	6.89	330.4	323.1	55.94	2065.8	491.6
80	40	6.89	218.2	306.8	37.52	1776.4	331.8
100	40	6.89	106	290.5	19.1	1487	172
120	40	6.89	58.7	222.88	17.3	1276	130
140	40	6.89	55.9	178.94	14.1	1189	200
160	40	6.89	44.3	172.48	13.1	1118	145
180	40	6.89	55	140.08	15.1	1053	286
200	40	6.89	59	141.6	16.3	1074	294
220	40	6.89	62.4	140.9	19	1122	301

Table 2. Raw Efluent constituents

Ferri Flocc (ppm)	**Raw**
6611	40
PH	6.89
Turbidity (NTU)	1100
Phosphates (ppm)	419.27
Nitrates (ppm)	116.2
COD (ppm)	4268
TSS (ppm)	1119

Table 3. Constituents composition in treated Effluent

Ferric Chloride (ppm)	**COD (ppm)**	**Phosphates (ppm)**	**Nitrates (ppm) 3246**	**TSS (ppm)**	**Turbidity (NTU)**
0	1907	364	112.9	538	300
20	1767	330.658	92.4	463	246.84
40	1627	297.316	75.6	388	193.68
60	1487	263.974	55.1	313	140.52
80	1347	230.632	32.6	238	87.36
100	1207	197.29	29.8	164	34.2
120	1067	188.71	25.1	93	29.7
140	1070	167.8	20.8	89	35.7
160	1089	132.66	13.5	154	35.6
180	1115	117.13	11.3	155	35.8
200	1192	115.24	11.5	157	36
220	1228	114.23	10.8	158	36.4
240	1312	114.68	11.6	160	36.9

The usage of glass Beakers in the sedimentation of suspended solids was the simulation of sedimentation unit of operation in the plant. At the end of this research the optimisation methodology may either require a correction, replacement or addition of the unit of operation.

Ferriflocc; the mixture of ferric chloride and Poly Amide, did not show any visible floccs during the experimental tests but the effects of the Ferriflocc were observed when a constant concentration of Flocculent was added in all five samples. Then the sample Clarity was increasing with the increasing concentration of the coagulant. The clarity increased until at 180 ppm, then it started decreasing and the water was becoming more Hazy, then the dosing of ferriflocc was stoped as the water became hazier. The floccs that formed were however slow to settle. Coagulants with Floccs that are slow to settle, are not good to be used as sedimentation aids especially at high flow rate systems, they rather require very huge settling tanks. They are ideally good reagents for Dissolved air flotation (DAF) reactors. DAF reactors would make every sediment in the reactor to float on the water surface by attaching all the solid waste to air bubbles. The tests were repeated to confirm the coefficient of confidence

Ferric chloride as a coagulant did produce some floccs that grew bigger as the flocculent was added, but the floccs were also slow to settle they took about 3.5 minute to settle at the bottom of a 500ml Beaker. Ferric Chloride can also be good to be used in a DAF reactor. It would not be efficient to be used in a settling tank

Aluminium Chloro hydrate with poly amide as a flocculent produced large floccs that settled completely in 50 seconds. The combination was the best sedimentation aid. These are Ideal Floccs to be used in a clarifier since they settle very well.

The three coagulants did remove suspended solids, that was witnessed by the sediments that settled at the bottom of the beakers

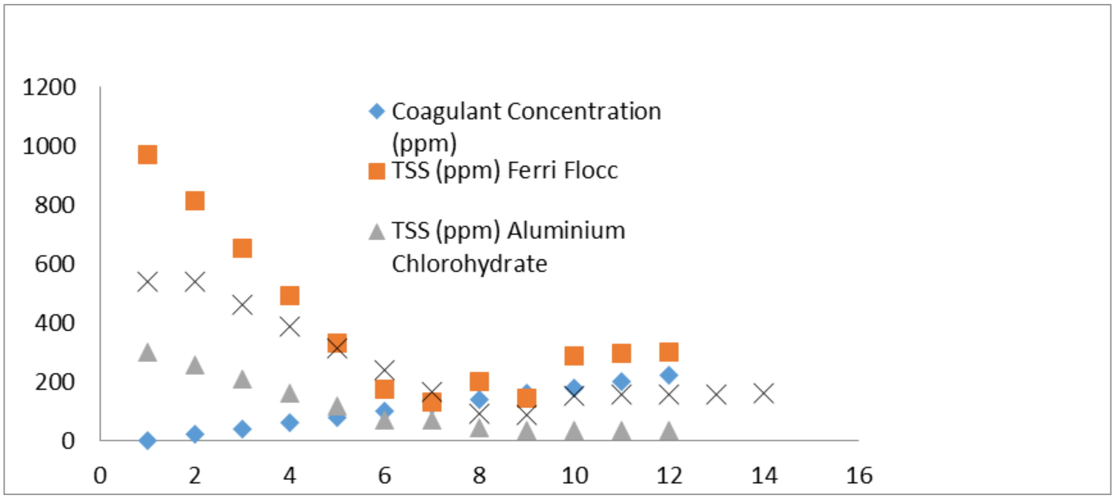

Figure: 2 Graphical illustration of TSS v/s Coagulant concentration

Turbidity is directly proportional to suspended solids. The lesser the suspended solids the lesser the turbidity. There is a direct relationship between the two, even their removal from water take the same Trend. It can be proven graphically, Turbidity Graphs look similar to TSS graphs. Compare The analysis of the Turbidity was then conducted on turbidity meter to confirm the visual observation that was observed. The Turbidity meter readings also confirmed the same. The lowest turbidity of 50 NTU was observed at 180ppm of ferriflocc and 40ppm of poly amide polymer. The following graphical illustration will show the same as discussed.

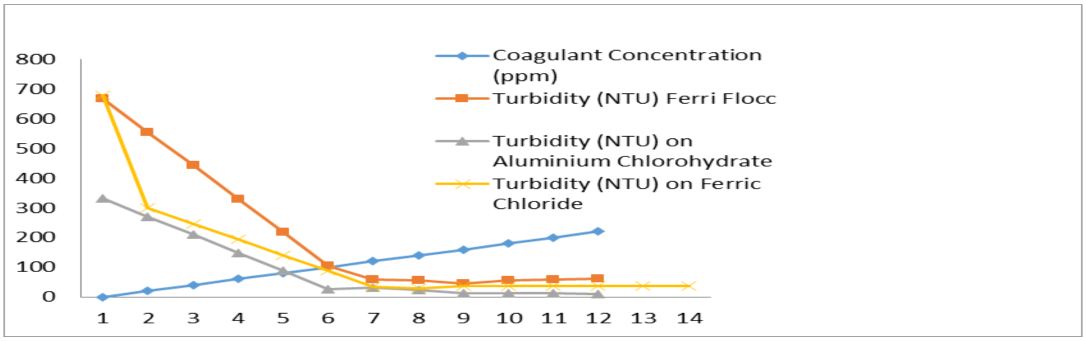

Figure 3: Graphical illustration of turbidity v/s coagulant concentration

Ferriflocc do remove the suspended solids and the other undesired substances in the waste water. It is of vital importance to remove as much suspended solids as possible because 55% of effluent waste water is composed of suspended solids [10]. Once Ferriflocc become an excess reagent in the water then I start becoming a pollutant rather than a treatment reagent. This can be witnessed by the concentration of the COD versus the concentration of the coagulant. The COD was also lowest at 180ppm o the Ferriflocc is dark brown in colour

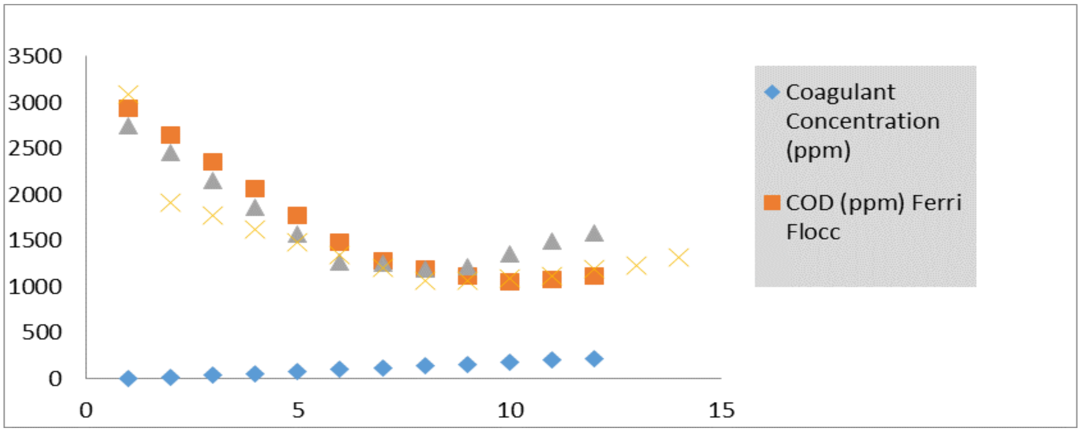

Figure 4. Graphical illustration of COD v/s coagulant concentration

The COD curves take the same trend, COD decrease with increasing concentration of coagulants. The COD reach a point where the chemical coagulant is not required anymore, if extra coagulant/ flocculent is being dosed then the COD concentration start going up. This because when the coagulant exceed the saturation point it become an excess reagent and will start becoming a pollutant rather than a treatment reagent.

Phosphates cause eutrophication, which is the abnormal growth of algae. This algae will compete for oxygen against aquatic life. This in turn has a harmful effect on aquatic life, resulting in a reduction in biodiversity [8]. Phosphates are removed by precipitation reaction. It take place in a form of exchange reaction where the phosphates react with the metal in coagulant forming metal phosphate, be it aluminium or Iron.

$$Al_2(SO4)_314H2O + 2PO4^{3-} \rightarrow 2AlPO4 + 3SO_4^{2-} + 14H_2O$$

Ferrifloc reduced Phosphates by 62.16%, in actual facts they were reduced by 66.39% when considering the raw sample. The effluent plant that is being optimised, received raw water at the phosphates level of 419.27mg/L and could produce an effluent of 372.45mg/L. this was an 11.16% removal of phosphates. The laboratory test proved that ferriflocc can reduce phosphates from 372.45mg/L to 140.9mg/L which make it to be 62.16% efficient if considering the effluent and 66.39% when considering the raw sample (influent)
Aluminium Chloro hydrate removed the Phosphates by 64.15% when only considering the effluent sample but in actual facts the, the Phosphates were removed by 74.80% if considering the influent sample which came the concentration of 508.02mg/L. The ferric Chloride removed the Phosphates by 68.61% when considering the effluent sample but in actual facts by 79.74%. The plant could remove the Phosphates by 35.46% and application of chemicals could add 44.28% efficiency on the facilities making it 79.74% Efficient. The Phosphates Graphs are having similar shapes to the suspended solids Graphs and the turbidity. This proves that the phosphate precipitate and settle down in a form of suspended solids. There is an interrelation ship between the three parameters [8].

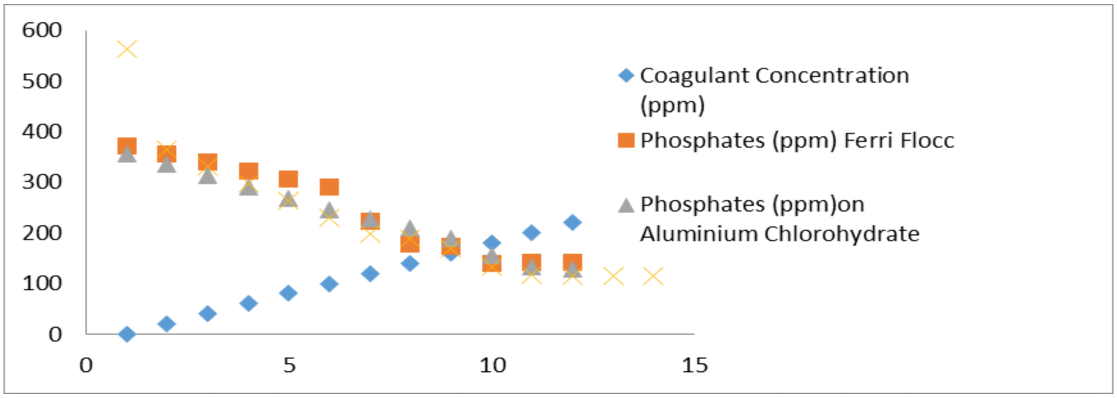

Figure 5 Graphical representation of Phosphates v/s coagulant

Nitrates are also one of the substances responsible for growing algae in rivers and lakes. This result in eutrophication which does not support aquatic life. Nitrates can also cause Methemeglobinemia a disease that can cause death to infants. It can be removed by de-Nitrification from water. Many researchers such as Zang, Su and Puls came with different perspectives of de-Nitrification reaction. The following is the chemical reaction of zero valent Iron and Nitrate.

$Fe^0 + 2NO_3^- + 6H_2O \longrightarrow N_2 + 5Fe^{2+} + 12OH^-$

$4Fe^0 + NO_3^- + 7H_2O \longrightarrow NH_4^+ + 4Fe^{2+} + 10OH^-$

The Nitrates Curve resembles more the suspended solids curve. They all look similar. The ferriflocc removed Nitrates by 88.83%. The Aluminium Chloro hydrate removed the Nitrates by 71.60 and the ferric chloride removed he nitrates by 90.78%.

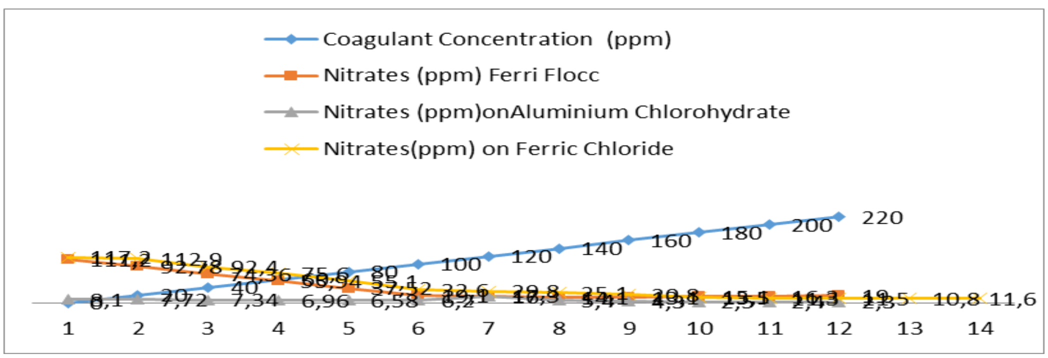

Figure 6: Graphical representation of Phosphates v/s coagulant

Conclusion

The study seem successful since the Chemical reagents applied in the Project proves to be appropriate in the Quality improvement of the abattoir waste water treatment A methodology to optimize the waste water treatment plant of the abattoir at Ekurhuleni east of Johannesburg can be invented to correct the current status quo. The researcher recommends that a clarifier be installed in order for the abattoir waste water treatment plant to practice sedimentation activities in the plant to further improve the waste water Quality.

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Dr Paul A. Ozor obtained a bachelor's degree (B.Engr) in Mechanical/Production Engineering at Enugu State University of Science and Technology, Nigeria. He worked as project manager with some Engineering Companies before proceeding to Department of Mechanical Engineering, University of Nigeria Nsukka (UNN) for higher studies, and specialized in Industrial Engineering and Operations Management. He obtained both Masters and PhD degrees in 2008 and 2015 respectively from UNN. He has been a teaching and research staff of UNN for over a decade. He is a Professional Member of Nigeria Society of Engineers. Dr Ozor is currently a TWAS-NRF research fellow to University of Johannesburg, South Africa, and had been awarded the Association of Common Wealth Universities' (ACU) early career scholarship in 2014. His research interests include Industrial Operations modelling, Quality management, Systems Analysis, Reliability Engineering, with special emphasis on System Sustainability, Failure mode effects and criticality analysis (FMECA), Safety and Risk assessment (SRA) as well as Environmental influence modelling, including Waste Management, Water and Energy nexus.

Professor Charles Mbohwa is an established researcher in the field of sustainability Engineering and Energy. He specializations include Sustainable Engineering, Energy Systems, Life Cycle Assessment and Bio-energy/Fuel feasibility and Sustainability, with general research interests in Renewable Energies and Sustainability issues. Professor Mbohwa has presented at numerous conferences and published more than 150 papers in peer reviewed Journals and Conferences, with 6 book Chapters and one book. Upon his graduating with B.Sc Honours in Mechanical Engineering at the University of Zimbabwe in 1986, He was employed as a Mechanical Engineer by the National Railways of Zimbabwe. He bagged a Masters (M. Sc.) in Operations Management and Manufacturing Systems in 1992, with a distinction from Department of Manufacturing Systems Engineering, University of Nottingham, UK, and completed his doctoral studies in Engineering (Production Systems focusing on Energy and life cycle assessment) from Tokyo Metropolitan Institute of Technology, Tokyo, Japan in 2004. Professor Mbohwa is an NRF-rated established researcher and had been a Fulbright scholar visiting the Supply Chain and Logistics Institute at the School of Industrial and Systems Engineering, Georgia Institute of Technology. In January 2012, he was confirmed as an established researcher making significant contribution to the developing fields of Sustainability and Life Cycle Assessment. He has produced high quality body of research work on Southern Africa. He is an active member of the United Nations Environment Programme/Society of Environmental, Toxicology and Chemistry Life Cycle Initiative, where he has served on many taskforce teams. Prof. Mbohwa is a fellow of Zimbabwean institute of Engineers and a registered Mechanical Engineer with the Engineering Council of Zimbabwe. He has also visited more than eighteen Countries on research and Training engagements.