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Application of Statistical Techniques for Examination of Piggery Wastewater in Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author NEN provided technical support, supportive ideas and revised the manuscript. Author BUO wrote the first draft of the manuscript, managed the literature searches, analyses of the study, managed the experimental process and reporting. Both authors read and approved the final manuscript.

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ABSTRACT

This study presents the results obtained from a comprehensive investigation of pollution indicators of piggery wastewater from a stabilisation pond in Nigeria in a laboratory scale. Experiments were conducted to predict treatment efficiency of the various stabilisation ponds in order to identify best retention time required for optimal treatment to produce effluent of good quality. The observations obtained from the concentration of the pollutants showed that there was significant reduction of pollutants in all the ponds with anaerobic pond generally showing the highest removal rate. Chemical oxygen demand (COD) removal was highest in the facultative pond which could be attributed to algal activities present in pond. Further statistical interpretation of the results was done based on the probability (*p*) values. All the main effects were found significant ($p < 0.05$) at the 5, 10, 15, 20, 25 and 30 day retention times at 5% confidence level, the interactions between wastewater quality variables were also found to be significant in anaerobic, facultative and maturation ponds. Statistical techniques employed for the evaluation and interpretation of large complex data sets used in this study provide a better understanding of wastewater quality and thus assist in the decision making process during design prototype for the effective management of water resources.

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1. INTRODUCTION

Intensive pig breeding changes the natural clime of an area through processes of acidification, eutrophication and an increasing greenhouse effect (the emission of carbon monoxide, methane and nitrogen oxide) [1]. Waste from piggery has very high concentrations of organics and nitrogen which results in the degradation of water bodies and the environment at large. Other environmental problems associated with piggery wastes include heavy metals such as zinc and copper [2] and antibiotics [3]. The environmental impacts of a poorly managed intensive pig production facility can be enormous. Wastewater from a poorly managed piggery may increase risk of wastewater pollution to local waterways, produces and releases offensive odour into the atmosphere. In contrast, a properly designed and managed piggery efficiently maintains control of odour emissions and outputs very little greenhouse gas [4].

Waste stabilization ponds are constructed through excavation and compaction of earth to create reservoirs capable of holding wastewater for predetermined periods of time [5]. Waste stabilization ponds are designed to provide a controlled environment for wastewater treatment [6]. Waste stabilisation ponds WSPs have been known for simplicity of construction and operation [7]. The WSP is the only interface between raw sewage and the environment [8]. The best known wastewater treatment facilities for developing countries include the WSP and it operates extremely well in tropical regions at low-cost [9].

According to [7], adopting the WSPs for treatment of wastewater is considerably cheaper when compared to other methods provided the cost of the land is minimal. Wastewater treatment by WSPs employs natural processes in improving wastewater effluents; this has been employed by countries for over 3, 000 years [10]. During treatment of waste in the WSP, the pathogens are progressively removed along the pond series with maturation pond having the highest removal efficiency. Effective wastewater treatment has numerous benefits such as environment protection, public health improvement and treated water recycling.

Systematic environmental assessment and evaluation of wastewater quality variables is paramount for the prediction of wastewater properties before, during and after treatment process. Application of statistical technique in the analysis of wastewater samples has the advantages of explaining the observations, ability of predicting removal efficiencies, study of the relationship between the various variables, and formulation of the models for substrate removal. Various tools were utilised during analysis such as the analysis of variance (ANOVA), correlation coefficient, variance amongst others. Statistical analysis also provides valuable information on process design of a wastewater treatment plant based on mathematical models, thus enabling optimization of treatment process. This research intends applying statistical tools for the interpretation of the results of the quality of the wastewater.

2. MATERIALS AND METHODS

2.1 Algal Culturing

Collection of algae sample was from an existing pond of St. John's seminary, Okpuno and existing drainage works within the Nnamdi Azikiwe University, Awka. Wastewater samples were delivered to the Springboard laboratory, which is located in Awka, Anambra state. The facultative and maturation ponds were operated for several weeks from its initial setup on the 20th of February, 2015, to enable cultivation of viable cultures with tolerance to nitrogen, TDS, pH, COD and phosphate conditions (Plate 1). After successful cultivation of culture, raw piggery effluent was gradually added into ponds on the 25th of January. Ponds were gradually fed with wastewater from the equalization basin. After successful inoculation and adaptation of algae in wastewater, the ponds were continuously fed with effluent at a flow rate of 0.024 m^3/d until water from aquarium was completely replaced with wastewater.

Anaerobic pond has a freeboard of 50 mm to allow for a total water volume of 0.204 m^3. Facultative and maturation pond has freeboard of 30 mm and 20 mm giving a total pond volume of 0.1056 m^3 and 0.0704 m^3 respectively. Equalization basin was positioned on a steel stand of 1.3 m high, anaerobic pond was placed

Plate 1. WSPs showing (1) inoculated algae before introduction of wastewater (2) Algal bloom following wastewater injection in pond

Table 1. Dimensions of waste stabilization ponds (Prototype)

	Anaerobic pond, A	Facultative pond, F	Maturation pond, M
volume (m^3)	11696.40	3242.55	1178.31
Area (m^2)	2339.05	1852.60	1178.50
Length (m)	68.40	60.87	48.55
Width (m)	34.20	30.44	24.27
Depth, actual (m)	5.00	1.75	1.00
Depth + freeboard (m)	6.00	2.50	2.00

Table 2. Dimensions of Laboratory Scale Models of waste stabilization ponds

	Anaerobic pond, A	Facultative pond, F	Maturation pond, M
Volume (m^3)	0.196	0.096	0.064
Area (m^2)	0.24	0.32	0.32
Length (m)	0.60	0.80	0.80
Width (m)	0.40	0.40	0.40
Depth – actual (m)	0.80	0.30	0.20
Depth + freeboard (m)	0.85	0.33	0.22

on an improvised concrete platform while facultative and maturation pond models were positioned on the laboratory workbench of 1 m height to ensure a flow by gravity.

2.2 Statistical Technique Employed for Enumeration

Results of experimental works are presented below with particular reference to the depletion and percentage removal efficiency of the various parameters. This investigation evaluated the extent and efficiency of waste stabilization ponds in treating piggery wastewater. The nutrient and pathogenic removal processes occurring in ponds includes physical and biological processes which employ a wide range of diversity of organisms in remediation of wastewater. These organisms include bacteria, fungi, and algae [11]. These organisms may originate from air, spoil and animals cohabiting in wastewater.

3. RESULTS AND DISCUSSION

3.1 Statistical Analysis of Waste Stabilisation Pond

As the experiments were conducted to predict treatment efficiency of the various stabilisation ponds, the results obtained from the concentration pollutants showed that there was significant reduction in all of the ponds with anaerobic pond generally recording highest depletion. From Table 3, chemical oxygen demand (COD) had a higher depletion rate in the facultative pond (SD = 196.77) which could be attributed to algal activities present in pond and prolonged retention time.

3.2 One Way and Two-factor ANOVA

One way analysis of variance (ANOVA) conducted for nitrate shows that nitrate concentration in the ponds for all hydraulic retention times (HRT) significantly reduced ($p<0.05$) as shown in Table 4. This agrees with the results of removal efficiency. Subsequently, significant difference exists for nitrite concentration in ponds for retention times of 10 to 30 days (Table 4), which also agrees with results of removal efficiency presented in Table 5.

Statistical significant difference between the anaerobic, facultative and maturation results obtained ($p<0.05$) was also observed for phosphate as differences between ponds were greater than expected. This agrees with results of removal efficiency as presented in Table 5. Subsequently, significant difference also exists between effluent and influent to ponds for retention times of 10 to 30 days. Analysis conducted for the chemical oxygen demand shows that effluent concentration in all the ponds were significantly varied as can be seen from result obtained ($p<0.05$), which implies there is a decrease from one pond in series to another as shown in Table 5 and Table 6. One way analysis of variance (ANOVA) conducted for TDS shows that there is statistical significant difference in the quality between the anaerobic, facultative and maturation results obtained ($p<0.05$) in all the ponds, as differences between ponds were greater than expected. This agrees with results of removal efficiency.

Table 3. Basic statistics of analysed variables

	Minimum	**Maximum**	**Mean**	**SD**	**Variance, v**
			Anaerobic pond		
HRT (day^{-1})	**5**	**30**			
NO_3^- (mg/l)	4.39	13.14	8.1975	2.41780	5.846
NO_2^-(mg/l)	1.68	5.27	3.1986	1.13022	1.277
PO_4^-(mg/l)	8.54	26.44	15.3693	5.19138	26.950
COD (mg/l)	317.00	917.00	434.2055	118.32969	14001.916
TS (mg/l)	4940.00	14520.00	8276.4384	2796.87989	7822537.139
TDS (mg/l)	2340.00	9620.00	6260.2740	1692.48172	2864494.368
TSS (mg/l)	420.00	7800.00	2016.1644	1591.22824	2532007.306
Temperature (℃)	26.00	32.00	29.2105	1.37904	1.902
pH (mol/L)	5.90	7.41	6.5508	0.42041	0.177
Turbidity (NTU)	310.00	849.00	671.5395	201.60830	40645.905
			Facultative pond		
NO_3^- (mg/l)	2.76	13.14	5.6921	2.70291	7.306
NO_2^-(mg/l)	1.61	5.27	2.6733	0.95353	0.909
PO_4^-(mg/l)	7.62	26.44	12.2379	4.38447	19.224
COD (mg/l)	8.00	917.00	276.2919	196.76907	38718.067
TS (mg/l)	3398.00	14520.00	6671.6649	2646.75013	7005286.257
TDS (mg/l)	2340.00	9620.00	5066.0541	1612.26485	2599397.932
TSS (mg/l)	260.00	7800.00	1605.6108	1346.64369	1813449.239
Temperature (℃)	26.00	32.00	29.3866	1.25505	1.575
pH (mol/L)	5.90	7.41	6.8684	0.37340	0.139
Turbidity (NTU)	28.00	849.00	314.6237	315.53678	99563.459
			Maturation pond		
NO_3^- (mg/l)	2.76	4.98	3.4046	0.58689	0.344
NO_2^-(mg/l)	1.61	3.08	2.2497	0.53611	0.287
PO_4^-(mg/l)	7.62	11.97	9.4327	1.51470	2.294
COD (mg/l)	8.00	616.00	112.8571	158.56383	25142.488
TS (mg/l)	3398.00	6280.00	4641.0357	1033.37491	1067863.708
TDS (mg/l)	3120.00	4680.00	3622.8571	452.50701	204762.597
TSS (mg/l)	260.00	1880.00	1018.1786	593.29555	351999.604
Temperature (℃)	27.00	32.00	29.5085	1.13522	1.289
pH (mol/L)	7.00	7.30	7.1085	0.08961	0.008
Turbidity (NTU)	28.00	86.00	45.5763	18.80132	353.490

SD - Std. Deviation

Table 4. ANOVA results (One way) for 5, 10 and 15 day retention time

Parameter (s)	HRT (d^{-1})	F	p- value	F critical
Nitrate (mg/L)	5	785.613	9.11×10^{-45}	3.145
	10	183.500	1.1×10^{-27}	3.136
	15	150.283	5.87×10^{-12}	3.555
Nitrite (mg/L)	5	22.186	4.27×10^{-08}	3.136
	10	5.866	1.09×10^{-02}	3.555
	15	45.480	1.97×10^{-05}	4.256
Phosphate (mg/L)	5	96.329	9.54×10^{-20}	3.145
	10	92.717	6.77×10^{-20}	3.136
	15	13.888	2.25×10^{-04}	3.555
COD (mg/L)	5	15.576	3.7×10^{-06}	3.153
	10	609.042	1.41×10^{-40}	3.150
	15	1218.100	6.14×10^{-20}	3.555
TDS (mg/L)	5	51.627	1.09×10^{-13}	3.153
	10	47.956	3.61×10^{-13}	3.150
	15	2485.081	1.04×10^{-22}	3.555

Table 5. Removal efficiencies (%) of NO_3^-, NO_2^-, PO_4^-, COD, TS, TDS, TSS, Turbidity, TC, FC and HB in WSPs

Parameter/ t (day)	5	10	15	20	25	30
	Anaerobic pond					
NO_3^-	23.71	53.26	61.60	63.27	63.27	63.27
NO_2^-	24.64	59.27	66.40	67.41	67.62	67.41
PO_4^-	35.27	52.69	65.38	65.81	66.02	66.24
COD	50.00	61.63	64.24	65.12	64.53	64.80
TS	36.20	58.39	62.41	64.91	64.91	64.91
TDS	15.25	49.67	49.89	50.54	50.11	49.89
TSS	72.90	73.66	84.35	90.08	90.84	91.22
Turb.	1.06	26.97	56.30	62.90	63.49	62.66
	Facultative pond					
NO_3^-	53.26	71.79	76.29	76.63	76.96	76.96
NO_2^-	41.75	63.14	67.82	68.43	68.84	68.64
PO_4^-	51.18	61.08	65.16	65.59	65.81	66.02
COD	65.70	84.01	86.05	89.83	90.41	89.24
TS	32.04	64.77	66.99	68.10	68.52	69.35
TDS	34.64	53.59	54.68	55.34	55.56	57.52
TSS	27.48	84.35	88.55	90.46	91.22	90.08
Turb.	81.98	86.10	87.63	87.75	88.10	87.87
	Maturation pond					
NO_3^-	71.79	76.46	78.13	78.63	78.96	78.96
NO_2^-	46.23	64.15	68.23	68.84	69.04	69.04
PO_4^-	57.42	66.88	69.03	69.25	69.46	69.68
COD	79.36	97.67	97.91	98.55	98.84	98.55
TS	61.17	73.51	75.17	75.73	75.45	76.44
TDS	56.43	64.05	65.36	65.80	65.80	66.01
TSS	69.47	90.08	92.37	93.13	92.37	94.69
Turb.	92.34	95.88	96.47	96.70	96.70	96.35

Furthermore, ANOVA for two-factor without replication (Table 6) was conducted to examine relationship between the ponds and their individual retention times. Retention times considered were 5, 10, 15, 20, 25 and 30 days. Nitrate analysis for the two-factor ANOVA reveals that a very strong relationship exists between nitrite in the ponds (anaerobic, facultative and maturation), this was substantiated by p- value obtained (p = 0.0000174). Similar results were observed for the various retention times; similarity was noted between the retention times (p = 0.0039).This reveals that nitrate depletion between pond and the various retention time were significant and that appreciable treatment in systems and retention times was derived. Interaction of nitrite between ponds for the various detention times was significant (p = 0.0028) and between retention times significant values of p = 0.000022 were obtained. This reflects a significant reduction of nitrite between the ponds and retention times. Similarly, phosphate removal in pond was confirmed by the two- factor ANOVA interaction; reduction between ponds reflects significant value of p = 0.0023 while between retention times, phosphate reduction was significant (p= 0.0028).

Reduction of chemical oxygen demand in pond was also studied. COD reduction between ponds showed highly significant results (p = 0.0000000216), and appreciable between retention times (p= 0.00000156). The COD reduction may have been influenced by the various interactions and parameters. Correlation results in Table 7, Table 8 and Table 9 showed a strong relationship between solids removal and COD in the ponds. The TS, TDS and TSS were all significantly removed in ponds and this can be confirmed by 'p' value of 0.000064, 0.000018, and 0.0011 for the TS, TDS and TSS respectively. Reduction of these solids with respect to retention times is significant in TS (p = 0.000090) and TDS (p = 0.0018) only, however, TSS failed significance test as the p value obtained was > 0.05 value. The suspended solid removal between detention times were not significant and this can be seen from the variance obtained for TSS in the facultative (1056.87) and maturation pond (1415.75); significance variation was only in the anaerobic pond, and these may have influenced general system.

The temperature, pH and turbidity removal between retention were not significant. Temperature in the pond was between range of 28℃ and 32℃ which of cause varied very minimal between retention times and studied ponds. The pH variation in the ponds was significant (p= 0.00000033), the pH in the ponds ranges between 6.5 and 7.3, with the anaerobic pond having the lowest value. The pH in anaerobic pond is very essential as it influences the efficiency of the ponds. Variation of pH in the anaerobic pond is the highest (0.0134), while the facultative has the higher value (0.0015) than the maturation pond (0.00061) (A>F>M). However, interaction and/ or variation of pH between retention times was not significant (p= 0.545). Removal of turbidity was highest in the anaerobic pond (v= 26754.78) and lowest in facultative pond (v = 198.69). Reduction in waste stabilisation ponds was very significant (p= 0.000001) while turbidity removal with respect to the retention time in ponds were not significant (p = 0.23), which indicated that the retention time has an insignificant influence on the turbidity removal.

3.3 Correlation Analysis

Correlation analysis was performed to show how strong a linear relationship exists between two variables [12]. Correlation analysis performed shows that nitrate correlated strongly with nitrite (r = 0.963), phosphate COD (r = 0.815), TDS (r = 0.779) and turbidity (r = 0.951). It was noted that most of parameters correlated strongly with nitrate and nitrite in the anaerobic pond, implying that the decline or increase of these parameters may greatly impact on their depletion from the waste treatment plant.

Table 6. ANOVA Results (Two way) for 5, 10, 15, 20, 25 and 30 day retention time

Parameter (s)	Variation source	F	p- value	F critical
Nitrate (mg/L)	Rows (ponds)	39.776	1.74×10^{-05}	4.103
	Columns (HRT)	7.357	3.90×10^{-03}	3.326
Nitrite (mg/L)	Rows (ponds)	11.223	2.78×10^{-03}	4.103
	Columns (HRT)	25.333	2.24×10^{-05}	3.326
Phosphate (mg/L)	Rows (ponds)	11.866	2.29×10^{-03}	4.103
	Columns (HRT)	8.0495	2.79×10^{-03}	3.325
COD (mg/L)	Rows (ponds)	165.639	2.16×10^{-08}	4.103
	Columns (HRT)	44.949	1.56×10^{-06}	3.326
TS (mg/L)	Rows (ponds)	29.530	6.37×10^{-05}	4.103
	Columns (HRT)	18.554	9.02×10^{-05}	3.326
TDS (mg/L)	Rows (ponds)	39.665	1.76×10^{-05}	4.103
	Columns (HRT)	9.061	1.78×10^{-03}	3.326
TSS (mg/L)	Rows (ponds)	14.443	1.13×10^{-03}	4.103
	Columns (HRT)	1.253	3.55×10^{-01}	3.326

HRT – Hydraulic retention time

A strong correlation also exists as depicted in Table 7 amongst nitrate, nitrite, phosphate, COD, total solid, total dissolved solid, total suspended solid and turbidity. Temperature negatively correlated very poorly with nitrate, nitrite, phosphate, COD, total solid, total dissolved solid, total suspended solid and turbidity with 'r' value of -0.326, -0.377, -0.418, -0.363, -0.378, -0.254, -0.397 and -0.386. There was no correlation between pH and nitrate, nitrite, phosphate, COD, total solid which posed an impact on the wastewater. According to [13], pH of WSPs increases as the wastewater travelled across and this increase favours nitrate, nitrite and phosphate removal [14,15].

Table 8 shows results of the interaction of the parameters in the facultative pond. An examination on correlation result shows a strong positive correlation amongst nitrate, nitrite, phosphate, COD, total solid, total dissolved solid, and total suspended solid. Correlation between turbidity and other parameters in the pond reflects a weak positive interaction as shown by 'r' values of 0.495, 0.413, 0.337, and 0.294 for nitrate, nitrite, phosphate, and COD. There is no relationship between the temperature in the pond and all other parameters which implies that an increase or decrease in temperature does not influence the removal of the parameters while the pH in the pond weakly correlated with nitrite, phosphate, COD, total solid, and total suspended solid. The pH in facultative pond does not influence nitrate, total dissolved solid, and temperature of pond.

In the maturation pond, a strong positive correlation can be observed amongst nitrate, nitrite, phosphate, COD, total solids, total dissolved solid, total suspended solid and turbidity. The very strong positive interaction implies that there is a interrelationship between the parameters. A change in any of these parameters will lead to subsequent change in system performance. These strong relationships can be used in formulation of a model that can efficiently be used to predict the behavior of a parameter in the waste stabilisation pond. Examination of COD in the maturation pond shows that COD correlated strongly with solids and this might have slightly impacted on the turbidity value (r = 0.760). The temperature of maturation pond weakly correlated with total solid, total dissolved solid and total suspended solid; which indicates that an increase or decrease in temperature can lead to the reduction or poor removal of solids in the pond. Optimum pH in maturation pond was 7.1 and pH result obtained shows that there is no interaction between pH and any of the parameters as shown by Table 9.0. Absence of correlation between pH and all parameters implies that a change in value of pH will not impact significantly on the other parameters. Substrate removal is mostly favoured by an increase in pH as observed in anaerobic pond.

Table 7. Pearson correlation coefficient for anaerobic pond

Anarobic		NO_3	NO_2	PO_4	COD	TS	TDS	TSS	Temp.	pH	Turb.
NO_3	r	1									
	sig.										
NO_2	r	**.963****	1								
	sig.	.000									
PO_4	r	**.929****	**.944****	1							
	sig.	.000	.000								
COD	r	**.815****	**.854****	**.877****	1						
	sig.	.000	.000	.000							
TS	r	**.861****	**.864****	**.921****	**.879****	1					
	sig.	.000	.000	.000	.000						
TDS	r	**.779****	**.710****	**.735****	**.719****	**.863****	1				
	sig.	.000	.000	.000	.000	.000					
TSS	r	**.694****	**.772****	**.845****	**.789****	**.849****	**.466****	1			
	sig.	.000	.000	.000	.000	.000	.000				
Temp.	r	**-.326****	**-.377****	**-.418****	**-.363****	**-.378****	**-.254***	**-.397****	1		
	sig.	.006	.001	.000	.002	.001	.035	.001			
pH	r	-.179	.004	.034	.197	-.014	**-.333****	**.324****	-.187	1	
	sig.	.140	.975	.784	.105	.907	.005	.007	.124		
Turb.	r	**.951****	**.924****	**.892****	**.734****	**.823****	**.743****	**.665****	**-.386****	-.221	1
	sig.	.000	.000	.000	.000	.000	.000	.000	.001	.069	

*** Significant correlation ($p \leq 0.05$)*

Table 8. Pearson correlation coefficient for facultative pond

Facultative		NO_3	NO_2	PO_4	COD	TS	TDS	TSS	Temp.	pH	Turb.
NO_3	r	1									
	sig.										
NO_2	r	.967**	1								
	sig.	.000									
PO_4	r	.930**	.983**	1							
	sig.	.000	.000								
COD	r	.860**	.950**	.965**	1						
	sig.	.000	.000	.000							
TS	r	.895**	.842**	.776**	.713**	1					
	sig.	.000	.000	.000	.000						
TDS	r	.851**	.760**	.686**	.579**	.946**	1				
	sig.	.000	.000	.000	.000	.000					
TSS	r	.872**	.846**	.790**	.758**	.979**	.858**	1			
	sig.	.000	.000	.000	.000	.000	.000				
Temp.	r	.122	.167	.162	.191	.078	.067	.080	1		
	sig.	.375	.222	.238	.163	.573	.627	.561			
pH	r	.231	.324*	.290*	.386**	.327*	.170	.408**	-.055	1	
	sig.	.090	.016	.032	.004	.015	.214	.002	.690		
Turb.	r	.495**	.413**	.337*	.294*	.791**	.784**	.751**	.016	.220	1
	sig.	.000	.002	.012	.029	.000	.000	.000	.907	.107	

*** Significant correlation (p ≤ 0.05)*

Table 9. Pearson correlation coefficient for maturation pond

Maturation		NO_3	NO_2	PO_4	COD	TS	TDS	TSS	Temp.	pH	Turb.
NO_3	r	1									
	sig.										
NO_2	r	.923**	1								
	sig.	.000									
PO_4	r	.937**	.991**	1							
	sig.	.000	.000								
COD	r	.932**	.818**	.848**	1						
	sig.	.000	.000	.000							
TS	r	.893**	.974**	.970**	.755**	1					
	sig.	.000	.000	.000	.000						
TDS	r	.909**	.975**	.971**	.774**	.984**	1				
	sig.	.000	.000	.000	.000	.000					
TSS	r	.862**	.952**	.949**	.725**	.991**	.952**	1			
	sig.	.000	.000	.000	.000	.000	.000				
Temp.	r	-.253	-.309*	-.308*	-.197	-.286*	-.304*	-.267*	1		
	sig.	.060	.021	.021	.145	.033	.023	.047			
pH	r	.078	.171	.192	.160	.120	.122	.116	-.161	1	
	sig.	.568	.207	.157	.237	.379	.370	.396	.236		
Turb.	r	.817**	.903**	.908**	.760**	.866**	.884**	.833**	-.266*	.190	1
	sig.	.000	.000	.000	.000	.000	.000	.000	.047	.161	

*** Significant correlation (p ≤ 0.05)*

Removal of organic matter which mostly is in form of both suspended and dissolved solids can be greatly influenced if the solids removal is effective. The minimal effect of temperature on the COD and solid in the ponds reflects effective solid reduction in the maturation pond compared to anaerobic. The very weak correlation of turbidity with temperature may reflect the algal cell density as noticed in facultative and maturation pond and subsequent reduced removal rate of nitrate, nitrite, and phosphate.

4. CONCLUSIONS AND RECOMMENDATIONS

Analysis carried out on wastewater from piggery farm shows significant differences in almost all parameters studied in the anaerobic, facultative and the maturation pond which reflects the efficiency of system in the treatment of piggery wastewater. The drastic reduction in the chemical oxygen demand in the facultative pond (S.D = 196.77) attests to the fact that the facultative pond is a very vital part of the waste stabilisation system and hence the design stage is an important facet of the system. Untreated wastewater discharged into the environment can adversely influence health of humans and the environment. Proper treatment of wastewater of piggery origin to specification is very vital and must be adequate monitored to ensure healthy and pollution free environs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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