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Changes in *in-situ* water characteristics of cassava wastewater due to the activities of indigenous microorganisms

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Abstract

Microorganisms play essential role in the degradation processes of wastewater depending on the physical, chemical and biological characteristics of the indigenous microorganisms present in the wastewater. This study evaluated the changes in in-situ water quality characteristics of cassava wastewater due to the activities of indigenous microorganism. Replicate samples of cassava wastewater were obtained from a smallholder cassava processor in Ndemili, Delta state, Nigeria. The effluents were analyzed for in-situ characteristics at 0, 3, 6, 9, 12, 15 days. The results ranged from 3.93-6.47 pH, 1.93–2.70mg/l dissolved oxygen, 10.73-14.17 conductivity, 7.18-9.71g/l total dissolved solid, 28.10–28.63°C temperature, 870.33-1304.33NTU. There was significant variations ($p<0.05$) among the various days of exposure. pH tended towards alkalinity, conductivity, total dissolved solid, dissolved oxygen were in a decline trend as exposure period increased unlike turbidity that elevated as exposure time increased. Temperature fluctuated between the various days. This study revealed that there are changes in in-situ characteristics of wastewater as exposure period increased. This is most likely due to the activities of indigenous microorganisms found in the effluents. This indicates that even without treatments the in-situ characteristics of the wastewater is being enhanced toward limit of effluent to be discharged into the ecosystem.

Keywords: wastewater, in-situ water characteristics, indigenous microorganisms, variations

Introduction

Environmental degradation have been on the increasing trend mainly due to anthropogenic activities and to a lesser extent natural effects.[1–5] The degradation of the environment (air, soil, water, sediment) is affecting different life forms in these habitats. Sometimes physical infrastructures are also affected via corrosion of roofing materials by acid rain. As such, there is the need to protect the environment. In developing nations like Nigeria wastes management is a major problem. In many coastal communities, the means of managing wastes is direct discharge into the surface water resources.[6–10] Food processing wastes including those from oil palm processing,[11] cassava wastewater,[12,13] abattoir wastes[14] are discharged into the environment without treatment. Some of the organic wastes have been researched upon for appropriate management approach through biotechnological processes. For instance, the cassava waste water can be used to produce bioethanol, culture medium for the production of *Saccharomyces cerevisiae*.[15–19] Probably due to the potentials of microorganisms in management of organic wastes research have been carried out on the role of microorganisms on different wastewater.

Despite the use of individual microorganisms in biotechnological processes, the use of indigenous microorganisms have been applied in eastern part of world for the extraction of minerals, enhancement of agriculture and waste management.[20] According to Kumar and Sai Gopal,[20] indigenous microbes are innate consortia of microorganisms that inhabit and thrive in the soil and other surfaces of living things inside and outside which have the potential of biodegradation, bioleaching, biocomposting, nitrogen fixation, improving soil fertility and production of plant growth hormones. Some microbes have the tendency to bio-adsorb many toxic compounds from the environment. For instances, Izah et al.,[13] reported the role of *Saccharomyces cerevisiae* in the removal of heavy metals in the cassava wastewater. Furthermore, authors have reported that yeast species such as *Torulaspora delbrueckii, Candida zeylanoides* and *Saccharomyces cerevisiae* improve the physicochemical characteristics of wastewater.[12,21–23] Thus, microorganisms play essential role in the well-being of mankind. Probably due to this, Kumar and Sai Gopal[20] reported the environmental restoration and safeguarding target through indigenous microorganisms in a native way to turn out the wastes substances into productive bioresources.

Typically, Nigeria is the world's leading producer of cassava accounting for over 20% of global production.[24–31] In Nigeria cassava wastewater are not treated before discharging into the ecosystem[12,13] and some of the physicochemical characteristics often exceed the limit of all effluents to be discharged into the environment (surface water and land) as specified by FEPA (1991).[32] The predominant microbial genera found in cassava wastewater include *Neisseria, Streptococcus, Staphylococcus, Bacillus, Entrobacter, Corynebacterium, Proteus, Lactobacillus, Acinetobacter, Pseudomonas, Marexalla, Micrococcus, Alcaligenes, Flavobacterium, Saccharomyces, Candida, Geotricum, Penicillium, Aspergillus* and *Mucor*.[18,33–36] These microbes are mostly environmental contaminants. Basically, the uniqueness of microorganisms and their often unpredictable nature and biosynthetic capabilities, given a specific set of environmental and cultural conditions, have made them likely candidates for solving difficult problems.[20] The utilization of indigenous microorganisms for economic, social and environmental benefits (including wastewater biodegradation) provides a suitable approach of protecting the environment from degradation. The indigenous microorganism aids in the decomposition of the cassava wastewater in the ecosystem. Hence, this study aimed at assessing the variations in in-situ water characteristics of cassava wastewater during degradation by indigenous microorganisms.

Materials and methods

Field sampling

Cassava wastewater containing palm oil used for this study was obtained from smallholder cassava processing mill in Ndemili, Delta state, Nigeria. The wastewater was packaged in plastic container and transported to the laboratory under ice. The effluent was used immediately in the laboratory.

Sample preparation and *in-situ* analysis

The wastes water was filtered with muslin cloth and then dispensed into 100ml conical flasks and slightly capped with cotton wool wrapped with aluminum foil. At 0, 3,6,9,12,15 days the effluent was analyzed for the in-situ characteristics viz: temperature, conductivity, salinity, and total dissolved solid (Extech EC400), turbidity (Extech Model TB400), pH and dissolve oxygen (Extech DO700). Control was also established by sterilizing the replicate sample of the effluents and preserved at <4ºC for 15 days. The control medium was removed from the cooling system 6 hours before the analysis. Prior to analysis the equipment was calibrated according to the manufacturers guide.

Statistical analysis

SPSS software version 20 was used to compute mean, standard error, analysis of variance at Significance level of α = 0.05 and Pearson's correlation matrix. For the one way analysis of variance, Waller-Duncan statistics was used to determine the source of the observed difference between the means.

Results and discussion

The in-situ water quality characteristics of cassava wastewater during decomposition by indigenous microorganisms for 15 days are presented in Table 1. While the Pearson correlation matrix of the in-situ parameters is presented in Table 2. The initial pH of the wastewater was 3.93 which tended towards alkalinity as the duration of fermentation by indigenous microbes increased. At 6 days the pH was 5.13 which increased to 6.47 after 15 days. The control showed a pH of 4.03. Basically, there was significant difference (P<0.05) among the various days of study. Furthermore, mean separation revealed no significant variations (P<0.05) at the initial and final of the control pH. The wastewater pH showed positive significant relationship with turbidity (r=0.919) and negatively correlate with conductivity (r=-0.962), total dissolved solid (r=-0.952), salinity (r=-0.933) and dissolved oxygen (r=-0.845) at p<0.01. The initial pH is within the values (2.5–5.07) that have been reported by authors in cassava wastewater.[37–39] In addition, the pH of the wastewater prior to degradation by indigenous microbes were lower than the FEPA [32] limits for effluents to be discharged into the ecosystem. As the period of decomposition increased the pH tended towards alkalinity but at day 15, the values were within the range of 6 - 9 recommended for effluent to be discharged into the environment as specified by FEPA [32]. Typically, several microorganisms have been reported to improve the pH of waste water including *Saccharomyces, Pichia* and *Candida* species.[40]

Table 1 In-situ water quality parameter cassava wastewater

Duration, Days	pH	Conductivity, µS/cm	Total dissolved solid, g/l	Salinity, ppt	Temperature, °C	Turbidity, NTU	Dissolved Oxygen
0.00	3.93±0.03a	14.17±0.12d	9.71±0.06e	7.07±0.04d	28.23±0.07ab	870.33±16.25b	2.70±0.10c
3.00	4.30±0.12b	13.02±0.10c	9.42±0.06de	6.79±0.16d	28.33±0.03ab	1040.00±21.22c	2.37±0.09b
6.00	5.13±0.09c	12.12±0.07b	9.18±0.14d	6.06±0.04c	28.27±0.09ab	1053.67±17.03c	2.17±0.12ab
9.00	5.53±0.09d	11.59±0.23b	8.25±0.06c	5.85±0.20bc	28.63±0.12c	1122.67±8.51d	2.03±0.09a
12.00	6.13±0.03e	10.80±0.33a	7.86±0.09b	5.50±0.14ab	28.10±0.06a	1245.33±10.17e	1.97±0.03a
15.00	6.47±0.09f	10.73±0.10a	7.18±0.08a	5.18±0.28a	28.43±0.12bc	1304.33±10.14f	1.93±0.03a
Control	4.03±0.03a	13.70±0.12d	9.70±0.14e	6.72±0.10d	28.17±0.07ab	735.67±10.14a	2.43±0.13bc

Each value is expressed as mean ± standard error (n=3); Different alphabets along the column indicates significant variation (*P*<0.05) according to Waller-Duncan Statistics

Table 2 Pearson's correlation matrix of the in-situ water quality parameter of cassava wastewater

Parameters	pH	Conductivity	TDS	Salinity	Temperature	Turbidity	DO
pH	1.000						
Conductivity	-0.962**	1.000					
TDS	-0.952**	0.910**	1.000				
Salinity	-0.933**	0.905**	0.909**	1.000			
Temperature	0.236	-0.248	-0.287	-0.158	1.000		
Turbidity	0.919**	-0.911**	-0.897**	-0.821**	0.260	1.000	
DO	-0.845**	0.861**	0.768**	0.798**	-0.251	-0.765**	1.000

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

N=21.

The conductivity of the wastewater at the beginning was 14.17mS/cm which declined as the period of decomposition increased. At day 9, the values were 11.50mS/cm and 10.73mS/cm at day 15. Generally conductivity values showed significant variation ($P<0.05$). But Waller-Duncan test revealed no significant difference ($P>0.05$) between days 6 and 9, days 12 and 15 and between day 0 and control. The conductivity of the wastewater showed negative significant relationship with turbidity ($r=-0.911$) and positively correlate with total dissolved solid ($r=0.910$), salinity ($r=0.905$) and dissolved oxygen ($r=0.861$) at $p<0.01$. The trend of conductivity reducing as fermentation period increased have been reported by authors using several diversity of yeast species (viz: *Torulaspora delbrueckii, Candida zeylanoides* and *Saccharomyces cerevisiae* [12, 21-23].

The initial total dissolved solid was 9.71g/l which declined to 7.18g/l after 15 days. The reduction in the total dissolved solid based on days was significant. Total dissolved solid showed a negative correlation with turbidity (r-0.897), and positively correlate with dissolved oxygen ($r=0.768$) and salinity ($r=0.909$) at $p<0.01$. At the initial and day 15 after fermentation of the cassava wastewater, the total dissolved solid values were still higher than the limit of 2000mg/l recommended by FEPA [32] for effluents to be discharge into the ecosystem. The decline in total dissolved solid values as the fermentation increased suggests the effects of the indigenous microbes. Again, yeasts such as *Torulaspora delbrueckii, Candida zeylanoides* and *Saccharomyces cerevisiae* have been reported to lower conductivity values of effluents [12, 21-23].

The initial salinity value was 7.07ppt which decreased to 6.06ppt at day 6 and 5.18ppt at day 15. The salinity of the wastewater showed significant difference ($p<0.05$). Salinity showed a positive significant correlation with dissolved oxygen ($r=0.798$) and negatively correlate with turbidity ($r=-0.821$) at $p<0.01$. The decline in salinity content may be associated to reduction in cations that may be present in the wastewater. Izah et al.[12] have previously reported that *Saccharomyces cerevisiae* has the tendency to reduce salinity content of cassava mill effluents.

The temperature of the wastewater ranged from 28.10–28.63ºC, being not significantly different ($p>0.05$) among the various period apart from day 9. The initial and final (day 15) temperature of the wastewater were within <40ºC limit recommended for effluents to be discharged into the ecosystem FEPA [32]. The values across the various periods suggest that temperature were not altered due to the activities of indigenous microbes in the wastewater. At room temperature, the values and trend reported in this study had some similarity with the work of Izah 30 on fermentation of cassava tuber for *fufu* production, Okowa et al. 41 on fermentation of maize medium for ogi production, Kigigha and Kombo 42 on fermentation of guinea corn.

The turbidity of the wastewater was 870.33 NTU at day 0, 1053.67 at day 6 and 1304.33NTU at day 15. The turbidity level showed a significant increase ($p<0.05$) as the fermentation period increased. Turbidity negatively correlated with dissolved oxygen ($r=-0.765$) at $p<0.01$. The increase in turbidity level as the fermentation progressed was possibly due to growth of microorganisms in the wastewater using the available nutrients. The trend in this study is similar to the work of Izah et al.[12] on the treatment of cassava wastewater using *Saccharomyces cerevisiae*.

The initial (day 0), day 3, day 6, day 9, day 12 and day 15 of dissolved oxygen were 2.70mg/l, 2.37mg/l, 2.17mg/l, 2.03mg/l, 1.97mg/l and 1.93mg/l respectively. Basically, there was significant difference ($P<0.05$). The initial dissolved oxygen values had some similarity with the work of Rim-Rukeh [36], Izah et al.[12] that recorded a value of 1.10–2.70 in cassava mill effluents. The decline in dissolved oxygen suggests that the oxygen content is being utilized by the microorganisms as the fermentation by the indigenous microorganisms increased.

The decline in conductivity, salinity, total dissolved solid and increase in turbidity and pH tending towards alkalinity suggests degradation of the cassava wastewater by indigenous microorganisms, thus possibly reducing the toxicity of the wastes water as well as the organic load. Again there was no significant variation between the initial value and control value for all the in-situ characteristics under study apart from turbidity. This suggests the possible role of indigenous microorganisms in biodegradation of the wastewater.

Conclusion

Indigenous microorganisms are vital for the degradation of wastewater. This study revealed that as exposure period of cassava wastewater increased the in-situ water characteristics is improved upon. The pH tended towards alkalinity, salinity, dissolved oxygen, total dissolved solid and conductivity decreased. Temperature fluctuates while turbidity increased. This suggests the role of indigenous microorganisms in the degradation of cassava wastes water which depend on the physical, chemical properties of the wastewater and characteristics and condition of the microorganisms found in the wastewater.

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Conflicts of interest

The author(s) declares that there is no conflict of interest.

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