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The Effect of Short Term Storage on Physico-Chemical and Organic Properties of Dairy Wastewater

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Abstract

The methods of handling, treating and disposing of farm wastes may adversely affect air, water and soil and may be a nuisance to those who dwell nearby. Large-scale dairy production system generates great quantities of wastewater. The effect of short-term storage on basic properties of dairy wastewater was examined in this work. Collection of water sample was through a sterilized white 10 L container at the point of discharge into the lagoon. The samples were stored for three, five and seven days before being taken for analysis in the laboratory for physico-chemical and biological properties. The iron content of the effluents sample ranged from 0.41mg/l to 0.52mg/l. The sulphate, phosphate, potassium and nitrate concentrations of the samples ranged between 11mg/l to 250mg/l when the samples were analyzed. The BOD measured in mg/l was not present in the raw samples but after five days, the BOD, COD and DO have great values. During aeration, the odor that would have polluted the laboratory where the experiment was performed was eliminated. The research can be extended by using the diary wastewater as soil amendment on a demonstration plot.

Keywords: *Farm wastes, effluents, BOD, COD, DO, soil amendment.*

Introduction

The recent changes in agricultural production methods have caused agriculturally related pollution to escalate, which is no longer considered minor. The changing agricultural practices have altered the traditional view of agricultural production from small scale to large scale production both in crop and animal production. The methods of handling, treating and disposing of the farm wastes may adversely affect air, water and soil conditions, and may be a nuisance to those who dwell nearby (Coker *et al*. 2001). Large scale dairy production system generates great quantities of wastewater. Potential pollutants from decomposing dairy manure and milking parlour are organic matter (protein and lipids), various gases including methane and ammonia. The major pollution associated with these wastes is surface and ground water contamination, and air pollution caused by odor, dust and ammonia. Dairy wastewaters are water which comes in contact with milk during milking or the cleaning of the milking plant or all the water that comes into contact with raw milk intended for the manufacture of dairy products (Olayinka 1990). Waste should be seen as an inefficient use of resources and many wastes that are being eliminated would have contributed to social and economic vitality and environmental quality. Hence the significance of waste management cannot be undermined. In actual sense, waste management is the collection, transport, processing or disposal of waste materials usually produced by human and animal activity in an effort to reduce their effects on human health and environment. Little work is being done on how best these wastes can be harnessed to add value to economic conditions of the populace. The high concentration of animal wastes in a small area and the disposal of the wastes on the soil have raised questions about surface runoff and groundwater quality problems.

All these aforementioned problems are typical of dairies throughout the world. It is

therefore important to look for alternative use of these diary wastewaters to alleviate some of the problems mentioned above. A large volume of dairy water is being dumped and left un-use in diary farms across Nigeria. Milk being high in protein generates a lot of odor if allowed to be stagnant for days.

A dairy is a facility for the extraction and processing of animal milk mostly from cows, sometimes buffalo, sheep, horses or goats for human consumption. As an adjective, the word dairy describes milk based or milk related products. A dairy farm produces milk and a dairy factory processes it into variety of dairy products. At some farms, these wastes are kept separate for treatment and disposal, at other farms, the liquid wastes are added to the manure in a storage pit to make the manure more amendable to transport and disposal as a liquid (Turner *et al*. 1994). However, dairy cattle manures are normally handed as solid slurry: concentrations in terms of mg/l have little meaning. Manure production from dairy cattle ranged from 33kg to 64kg with an average of 39kg/animal/day. Moisture contents average 80-88% of the weight of the manure. An average dairy cow will produce between 14 and 18 ton of animal waste/year. Manure has about 135kg to 180kg of dry matter/tonne. There are about 45kg of nitrogen, 1.8kg of P_2O_5, and 4.05kg of K_2O in each ton of wet manure defecated by the cow (Tomlison, *et al*. 1996).

Most dairy farms need no commercial fertilizer if they use the manure properly. In most cases, the manure produced can supply all the nitrogen, phosphorus, potassium and several other nutrients need for forage production. More than half the nutrients in dairy rations are excreted in manure. For example, one lactating dairy cow's manure can supply enough nitrogen for 1.5 acres of silage corn. (Tisdell and Breslin 1995**)**. Some nutrients leave the farm in milk, but most are excreted in manure and remain on the farm. Wastewater from the dairy milking center includes waste from the milking parlour (manure, feed solids, dirt.) and milk-house (bulk tank rinse water and detergents used in cleaning). Combining these wastes with manure and animal lot run off has the advantage of allowing a common disposal system for both types of waste. The resulting slurry can be stored in a pit until the contents of the pit can be applied to fields when the conditions are appropriate. By law, the waste storage facility must be 100 feet from all wells or source of water located on the farm (Coker, *et al*. 2001). Liquid and slurry storage systems use pipelines and/or pumps to move waste from barns or collection areas to the storage facility.

Some the diseases encountered by farmers on dairy farms includes leptospirosis, cowpox, tuberculosis (TB) and brucellosis.

Some heavy metals, such as copper and zinc, are essential nutrients for animal growth especially for cattle, swine, and poultry. However, such elements are often present in feed with concentrations far higher than necessary for animal health, along with other heavy metals such as chromium, lead, arsenic and cadmium. Farm animals excrete excess heavy metal in their manure which in turn gets spread as fertilizer, leading to soil and water pollution. The health hazards resulting from exposure to heavy metals in water include kidney problems from cadmium, nervous system disorders, kidney problems and headaches from lead; and both cardiovascular and nervous system problems from arsenic; which is also known to cause cancer.

Dairy manure and wastewater are excellent sources of nutrients for most agronomic, horticultural, and silvicultural crops. Proper management of this manure as nutrient sources is critical to promoting optimum plant growth and yield while protecting the environment. Optimum management of this resource includes, testing soil and manure regularly, setting realistic yield goals, applying manure in a uniform and timely fashion and practicing soil conservation and environmental sustainability (Gilley and Eghball 1998). Along with dressing the potential of animal production facilities to pollute water, sound management practices also improve animal health and make maintenance easier. Proper manure handling, storage, and disposal ensure that farmers reap the maximum fertilizer value from animal waste, while reducing risks of groundwater and

surface water contamination from improper application of nutrients.

Aerated lagoons have been a commonly used method of waste treatment for dairies that directly discharge to surface water. Generally these systems consist of several large ponds connected in series with floating surface aerators or submerged air diffusers. These treatment systems have quite a number of advantages which range from the long retention time, ability to absorb shock load, economic in construction material and operation to the small sludge which they generates which can allow for accumulation of sludge for years before dredging out (Westernman and Zhang 1997). The disposal of waste from a dairy processing industry is an integral part of the total production system.

To reduce the cost associated with conventional waste treatment, waste should be utilized as by product recovery and utilization should be studied as alternatives. These will serve as mechanisms for preventing intrusion of undesirable degradable materials into the environment. Different countries have defined waste polices on their respective national laws, but most dairy industries in Nigeria are owned by individuals and conglomerates, thus stringent action is placed on them if violated. Further legislation on waste treatment and disposal followed in 1974 with the control of pollution act, which controlled waste disposal on land (Greenberg 1992). Waste disposal authorities were required to prepare plans for the disposal of all household, commercial and industrial wastes likely to arise in their areas. The plans would be required to include information on the types, quantities and sources of wastes arising in the area; the methods of disposal, the site and equipment being provided and the cost (Obi and Ebo 1995). In view of this mandate regarding the Nigerian aquatic environment, the agency set national water quality guidelines and standards for various uses (Ali 1987).

The objectives of this project are to study the effect of storage techniques and aeration period on physico-chemical and biological composition of dairy wastewater and to ascertain the optimum storage duration that will guarantee the best use of dairy wastewater for soil amendment purposes.

Material and Methods

Study Site and Geographical Location

The study site where dairy wastewater sample collected for this work was taken was the Maizube Farms located at km 26 Minna-Bida Road, Minna Niger State. Maizube farm is on longitude 6.4^{o} and latitude 9.5^{o}. The farm has been in existence for over 20 years. The farm consists of four major sections which are the Dairy, Orchard, Green House and Field Crop Farm.

The Dairy

This is responsible for the rearing of exotic breeds of cattle called HOLSTEIN. These breed of cattle were brought to Nigeria from South Africa. They are mainly for the production of high quality milk and beef. Each cattle can give 20 to 30 L of pure milk daily. It can be on location for between eight to ten years before being slaughtered for meat. The milk given by the cattle are of high quality and are being used for the production of yoghurt, cheese, butter and fresh milk which are sold in many parts of the country. The operation and maintenance of the cattle is being done using up to date facilities of international standard.

Sample Collection

Collection of water sample for this project was done through a sterilized white 20-L container. Water sample was taken directly from the source of the dairy wastewater at the point of discharge into the lagoon. The sample collected was tightly covered and taken to the laboratory to be processed and analyzed. Two L of the sample was taken directly to laboratory for analysis, it was labeled sample I. To investigate the effect of storage duration and condition on the diary wastewater, the remaining sample was then divided into six two-L containers. The first portion was divided into two and labeled II_A and II_B. Sample II_A was stored in a well ventilated room for three

days undisturbed while sample II_B was kept in the same room but was being agitated by a turning stick every six hours for three days. After three days, the two samples were taken to the laboratory for analysis. The second portion was also shared into two and kept in the same environment. It was labeled III_A and III_B. Sample III_A was left undisturbed for five days while III_B was aerated every six hours for five days after which the two samples were taken to laboratory for analysis. The third portion was given the same treatment but for seven day storage under the same condition. They were labeled samples IV_A and IV_B. The samples after seven days were taken to laboratory for physico-chemical and biological examinations. The samples were analyzed using standard analytical techniques developed by American Public Health Association (APHA), World Health Organizations (WHO) and Federal Environmental Protection Agency (FEPA) Nigeria.

Results and Discussions

The results of the laboratory analysis for the samples are presented in Tables 1-4.

Discussion of Results

The dairy wastewater has a mild odor at the point of discharge but becomes objectionable as it get to the lagoon. As the samples are being stored for three and five days, the odor became more offensive as a result of biological degradation. However, for samples IIB and III B that are being aerated, the odor is not too serious since more oxygen is available for quick biological degradation. Also, for samples IVA and IVB stored for seven days, the odor is drastically reduced. This can be attributed to the fact that most biodegradation would have completed before seven days. The total dissolved solids of the whole samples are less when compared to WHO (1983/2004) and FEPA standard thus the polluting power of the waste is low. However, the value increased as the samples are stored for three and five days. This was evident from their values in Tables 2 and 3.Another point to note there is that the respective values of TDS and TSS are reduced when aerated. It can be affirmed from this that aeration alone will treat diary wastewater to appreciable level.

Dissolved Oxygen

Without free dissolved oxygen, there will be no survival of aquatic life forms in any water body. Streams and lakes therefore, simply become inhabitable to most aquatic life without free dissolved oxygen. At normal temperature water is said to be saturated with oxygen at 9mg/L. This saturation value decreases rapidly with increasing water temperature. DO of the samples ranged from 1.06mg/L to 1.10mg/L which values falls within the FEPA maximum level of 3mg/l and WHO of 5mg/L.

Table 1. Laboratory analysis results for raw sample.

S/no	Physico-chemical parameters	Sample I
1	Electrical conductivity (us/cm)	460
2	Temperature (^oC)	36 ^oC
3	Turbidity (FTU)	489
4	Color (Pt Co)	550
5	PH	6.4
6	Odor	odorless
7	Total hardness (mg/L)	570
8	Nitrate as nitrogen (mg/L)	18.3
9	Nitrate (mg/L)	27.3
10	Phosphate as phosphorus (mg/L	11.39
11	Phosphate (mg/L)	37.6
12	Iron content (mg/L)	11.63
13	Sulphate (mg/L)	11.6
14	Total alkalinity (mg/L)	130
15	Calcium (mg/L)	541.6
16	Magnesium (mg/L)	37.30
17	Potassium K^+ (mg/L)	320
18	Sodium (mg/l)	410
	Organic parameters	
19	Total dissolved solid (mg/L)	2,400
20	Suspended solid (mg/L)	438
21	BOD (mg/L)	-
22	COD (mg/L)	-
23	DO (mg/L)	880

Table 2. Laboratory analysis results of the samples after three days.

S/ no	Physico-Chemical parameters	Sample IIA	Sample IIB
1	Electrical conductivity (us / cm)	570	551
2	Temperature (^{o}C)	25 ^{o}C	26^{o}C
3	Turbidity (FTU)	527	554
4	Color (Pt Co)	580	673
5	PH	6.8	6.8
6	Odor	offen-sive	slightly offensive
7	Total hardness (mg/L)	575	590
8	Nitrate as nitrogen (mg/L)	21.2	23.0
9	Nitrate (mg/l)	29.3	35.6
10	Phosphate as Phosphorus (mg/L)	13.6	32.9
11	Phosphate (mg/L)	36.6	35.6
12	Iron content (mg/L)	9.46	9.97
13	Sulphate (mg/L)	17.5	25.6
14	Total alkalinity (mg/L)	194	187
15	Calcium (mg/L)	55.4	55.4
16	Magnesium (mg/L)	42.3	43.1
17	Potassium K^{+} (mg/L)	33.5	32.9
18	Sodium (mg/L)	41.3	41.5
	Organic parameters		
19	Total dissolved solid (mg/L)	298	335
20	Suspended solid (mg/L	329	420
21	BOD (mg/L)	69	45
22	COD (mg/L)	55	67
23	DO (mg/L)	1,020	1,154

Chemical Oxygen Demand

The beneficial effects of iron include: Chlorophyll synthesis, oxidation-reduction in respiration, constituent of certain enzymes and proteins. The iron content of the effluents sample ranged from 0.41 to 0.52mg/L. The samples had a low concentration of iron due to the low usage of metal in the abattoir. The iron concentration of the samples fall within the FEPA range of 20mg/L and slightly above that of WHO of 0.3mg/L.

Sulphate, Phosphate, Potassium and Nitrate.

The sulphate, phosphate, potassium and nitrate concentrations of the samples ranged between 11mg/L to 250mg/L when the samples were analyzed. Though, these values are not very significant in the raw samples, the values increased as the samples are stored for three and five days .It confirms the assertion that short term storage will have a slight adjustment on the bio-chemical properties of any organic wastewater. This implies that if the wastewater is to be stored for the purpose of using it for irrigation, it should not be stored more than five days as the crop macronutrients gets reduced as the samples are stored for seven days. The nutrients are suspected to have come from the types of food taken by the diary cows and milk constituents since the chief constituents of diary wastewater is milk. The four parameters under discussion are good materials needed by crops. This justifies that dairy waste can be used for agricultural purposes.

Table 3. Laboratory analysis results of the samples after five days.

S/ no	Physico-chemical parameters	Sample IIIA	Sample IIIB
1	Electrical conductivity (us / cm)	510	512
2	Temperature (^{o}C)	27 ^{o}C	29 ^{o}C
3	Turbidity (FTU)	830	894
4	Color (Pt Co)	410	515
5	PH	6.9	6.9
6	Odor	offen-sive	slightly offensive
7	Total hardness (mg/L)	580	575
8	Nitrate as nitrogen (mg/L)	28.9	27.6
9	Nitrate (mg/L)	41.2	40.0
10	Phosphate as Phosphorus (mg/L)	10.6	11.2
11	Phosphate (mg/L)	41.2	43.4
12	Iron content (mg/L)	7.2	7.4
13	Sulphate (mg/L)	18.2	25
14	Total alkalinity (mg/L)	133	134
15	Calcium (mg/L)	56.2	59.0
16	Magnesium (mg/L)	18.4	20.2
17	Potassium K^{+} (mg/L	30.3	32.9
18	Sodium (mg/L)	44.6	50.1
	Organic parameters		
19	Total dissolved solid (mg/L)	345	319
20	Suspended solid (mg/L)	331	402
21	BOD (mg/L)	75	40
22	COD (mg/L)	51	43
23	DO (mg/L)	1,113	1,172

Table 4. Laboratory analysis results of the samples after seven days.

S/ no	Physico-chemical parameters	Sample IVA	Sample IVB
1	Electrical conductivity (us / cm)	433	551
2	Temperature (^{o}C)	26 ^{o}C	26^{o}C
3	Turbidity (FTU)	406	554
4	Color (Pt Co)	339	673
5	PH	6.2	6.8
6	Odor	slightly offen-sive	very slightly offensive
7	Total hardness (mg/L)	450	502
8	Nitrate as nitrogen (mg/L)	13.3	25.0
9	Nitrate (mg/L)	22.1	19.4
10	Phosphate as phosphorus (mg/L)	8.9	88
11	Phosphate (mg/L)	29.4	26.0
12	Iron content (mg/L)	6.2	7.9
13	Sulphate (mg/L)	18.2	19.5
14	Total alkalinity (mg/L)	104	104
15	Calcium (mg/L)	43	41
16	Magnesium (mg/L)	12.0	13.1
17	Potassium K^{+} (mg/L)	33.1	32
18	Sodium (mg/L)	40.9	40
	Organic Parameters		
19	Total dissolved solid (mg/L)	251	223
20	Suspended solid (mg/L)	334	351
21	BOD (mg/L)	41	43
22	COD (mg/L)	50	51
23	DO (mg/L)	1,042	956

Calcium, Sodium, Magnesium and Iron

The same explanation goes for these trace elements. Calcium, sodium, magnesium and iron contents of the samples are not in large quantities but they have increased value as the samples are stored for few days. There is a remarkable change in the value of iron and magnesium contents, these values are suspected to come from the washed blood that might have mixed with the wastewater.

Conclusion

The effect of short term storage and aeration on properties of diary wastewater was investigated by storing the water for three, five and seven days with agitation every eight hours. The analysis carried out at the end of the experiment showed a significant change in physical, chemical and biological properties of the diary wastewater. The BOD measured in mg/l was not present in the raw samples but after five days, the BOD, COD and DO have great values. During aeration, the odor that would have polluted the laboratory where the experiment was performed was eliminated. The values of some chemical parameters like iron, calcium, phosphate, nitrate, and potassium also increased from within three days and reached maximum at five days but was reduced for the samples stored for seven days. It can be concluded from this simple experiment that if diary wastewater is to be used for irrigation purposes, it should not be use raw but the values therein can be optimized by storing them for five days. If stored without being disturbed, diary wastewater is an organic waste which can create unnecessary nuisance for people living around. This can be eliminated by incorporating aeration system that is too not expensive because of cost to benefit ratio.

Great number of research has been carried out on how to dispose off farm waste safely without endangering the environment. Since many dairies are heavily reliant on hydraulic flushing for manure management large volumes of wastewater are generated. These dilute wastewaters represent a significant bio energy resource if processed by anaerobic digestion. It is therefore necessary that these wastes are taken care of in view of their increasing magnitude on farms as the desired for increase agricultural production is achieved.

Recommendation

It is recommended that the analysis of properties of dairies wastewater on soil should be carried out periodically to ascertain the extent of which dairy water can be use as soil amendment and its best usage as fertilizer.

Further research should include the use of the diary wastewater as soil amendment on a demonstration plot. It can be used to raise maize, rice, cassava, yam, vegetables and any other crops. The nutrient values of the crop used need to be examined to ascertain whether the water can have any effect on the nutrient properties of the crops. Its effect on soil pollution can also be examined by carrying out the soil analysis after the experiment.

References

Ali, I. 1987. Wastewater criteria for irrigation in arid regions. J. Irrig. Drain. Engin. 113(2): 173-183.

Coker, A.O.; Olugasa B.O.; and Adeyemi, A.O. 2001. Abattoir wastewater quality in South Western Nigeria. Proc. 27th Water, Engineering and Development Centre (WEDC) Conference, Lusaka, Zambia, 20-24 August 2001, pp. 329-31. Loughborough University, Leicestershire, UK.

Gilley, J.E; and Eghball, B. 1998. Runoff and erosion following field application of beef cattle manure and compost. Trans. Amer. Soc. Agric. Engin. (ASAE) 41(5): 1289-94.

Greenberg, A.E. 1992. Standard methods for the examination of water and wastewater analysis. 18th ed. Amer. Public Health Assoc. (APHA), Washington, DC, USA.

Obi, M.E.; and Ebo, P.O. 1995. The effects of organic and inorganic amendments on soil physical properties and maize production in a severely degraded sandy soil in Southern Nigeria. Bioresource Technol. 51(2-3): 117-23.

Olayinka, A. 1990. Effects of poultry manure, corn straw and saw dust on plant growth and soil chemical properties. Ife J. Agric. 12(1): 36-44.

Tisdell, S.E.; and Breslin, V.T. 1995. Characterization and leaching of elements from municipal solid waste compost. J. Environ. Qual. 24(5): 827-33.

Tomlison, A.P.; Powers, W.J.; Van Horn, H.H.; Nordstedt, R.A.; and Wilcox, C.J. 1996. Dietary protein effects on nitrogen excretion and manure characteristics of lactating cows. Trans. Amer. Soc. Agric. Engin. (ASAE) 39(4): 1441-8.

Turner, M.S.; Clark, G.A.; Stanley, C.D.; and Smajstrla, A.G. 1994. Physical characteristics of a sandy soil amended with municipal solid waste compost. Proc. Soil Crop Sci. Soc. Florida 53: 24-26.

Westerman, P.W.; and Zhang, R.H. 1997. Aeration of livestock manure slurry and lagoon liquid for odor control: A review. Appl. Engin. Agric. 13(2): 245-9.