Research Article / Review Article

FUPRE JOURNAL 6(4): 23-32 (2022)

FUPRE Journal of Scientific and Industrial Research

ISSN: 2579-1184(Print)

ISSN: 2578-1129 (Online)

https://fupre.edu.ng/journal

Investigation of the Effectiveness of Drying Cow Dung and Sewage Sludge in Sand Drying Bed

Obianyo J. I. [1,*], **Ikpemo O. C.** [2,*], **Ohazurike E. E.** [3,*], **Ije, I.**, **Eboh S.** [4,*], **Obianyo L. I.** [5,*]

[1]*Department of Civil Engineering, College of Engineering and Engineering Technology, Michael* [2]*Okpara University of Agriculture, Umudike, Nigeria*

ARTICLE INFO

Received: 16/07/2022

Accepted: 20/09/2022

Keywords

Cow dung, Sand, Drying bed, Effectiveness, Investigation

ABSTRACT

This study investigated the effectiveness of dewatering cow dung and sewage sludge in sand drying bed. Sewage sludge and cow dung and sewage sludge were used to conduct seepage and evaporation experiments using standard methods. Results show that initial moisture contents were 81.01% and 74.07% for sewage sludge and cow dung. Comparison of Dewatering ratio between sewage sludge and cow dung on short term basis after 7 days of drying was 0.821, while dewatering ratio on long term basis between sewage sludge and cow dung after 13 days of drying was 1.03. Cow dung dewater faster through seepage than sewage sludge on short term by 17.92%, but on long term basis, better dewaterability of 2.99% was observed in sewage sludge. The initial volume of water in both cow dung and sewage sludge was 0.11342 m^3. Cumulative moisture loss from evaporation is higher in cow dung than in sewage sludge by 2.88%, because the final volume of water in both sludges were 0.050411 m3 and 0.052237 m^3 representing 44.45% and 46.06% moisture contents respectively. Overall percent moisture loss in sewage sludge was 55.55% and 53.94% in cow dung which indicate effective dewatering because of the insignificant difference between dewatering in sewage sludge and cow dung. It is concluded that sand drying beds can serve as better alternative to expensive cow dung rotary dryer.

1. INTRODUCTION

Sewage sludge is a problem because it pollutes the environment when disposed indiscriminately. In line with strict environmental regulations, there has been a rapid global increase in the generation of sewage sludge from wastewater treatment facilities (Spinosa, 2001; Duenser, 1996). Sewage sludge is watery, it contains 2% solids and 98% water so that water removal is important for volume reduction and ease of handling which can be achieved by gravity thickening or air floatation as an alternative (Agunwamba, 2001).

Sand drying beds are relatively inexpensive and provide dry sludge cake (Obianyo & Agunwamba, 2015). However, dewatering of various types of water from sludge have been studied by many researchers. It was observed that constant temperature (35°C) drying and dilatometric techniques for quantifying the bound water content of sludges, bound water content decreased following polymer or

Corresponding author:

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freeze-thaw conditioning of waste chemical and biological sludges (Robinson and Knocke, 1994). Using dilatometric technique to measure bound water in aerobically digested sludge, air liberated from the sludge sample during the freezing of the sludge water affects the quantity of unfrozen water and the precision of the dilatometry decreases with decreasing solids concentrations (Smith and Vesilind, 1995). In a study to induce better performance of existing activated sludge wastewater plants without modifying the physical structure of the plant. By means of two experimental models, the undisputable and rapid effect of talc/chlorite blend on the solid/liquid separation in sludge was established with a sludge volume index improvement by a factor of 2 to 3 within a few days compared with the control unit (Jantet et al., 1996). Chen et al. (1996), studied the feasibility of employing capillary suction time (CST) for characterizing the dewaterability of excess activated sludge, and showed that above 5 mL polymer/100mL sludge, the CST levels out at approximately that of water. However, the filterability of the sludge in such cases has not been measured if the CST equals that of water (Kajoie et al., 2000).

Due to high demand for meat, milk and hides, the quantities of cow dung generation have increased appreciably and have resulted in indiscriminate disposal of cow dung and associated environmental problem (Olaoye et al., 2018). Huge volumes of cow dung are generated from cattle ranches, slaughterhouses, feed lot farms and are disposed indiscriminately without treatment (Adeshiyan et al., 2010; Oyeleke, et al., 2003). There has been increase in generation of animal wastes such as urine, faeces, bedding, litter, feed remains, wastewater that is highly contaminated by animal manure bedding, wastes from washing and cleaning of animal pens and facilities for processing of animals (FAO, 1990). In space-constrained livestock settings, large quantities of animal wastes produced cause serious environmental problems if indiscriminately disposed (Morse, 1995).

In the UK, a larger share of cattle slurry manures is applied to grassland in spring than to tillage in autumn (Smith and Williams, 2016). To minimize ammonia emissions, low emission spreading techniques (LEST) are recommended, such as trailing hose, trailing shoe applicator, and shallow injection. These techniques can be mounted to a vacuum or pumped tanker (Misselbrook et al., 2002). Despite the potential of LESTs for the reduction in NH_3 loss of 40-90% compared to surface broadcast applications, surface broadcast techniques dominate the slurry application in the UK mainly due to cost (Smith and Williams, 2016). Composting is also commonly used for the disposal of animal manure to produce a stabilized fertilizer that is spread onto land with no or little odour, pathogens and nitrates. However, C and N losses decrease the value of the compost as fertilizer, and those losses contribute to greenhouse gas emissions (Cao et al., 2016).

In the pursuit of more sustainable wastewater treatment (WWT) processes, life cycle assessment (LCA) can be used as a suitable tool to evaluate the environmental performance of three scenarios for sludge disposal in a WWT plant. The first scenario involves final disposal of the dewatered sludge by truck to landfill after mechanical treatment. The second scenario assumes a circular pattern, with anaerobic fermentation of sludge to biogas and subsequent biogas use for electricity and heat cogeneration. The electricity is feedback to WWT, while heat is used for digestate drying, in addition to thermal energy from previously recovered waste cooking oil (WCO). The third scenario suggests an improved circular pattern where the dried sludge is further gasified for syngas production in which syngas is added to biogas for heat and electricity production. Scenario results suggest that increased circularity through recycling would be capable of reducing both the contribution to environmental impact categories and the fossil energy consumption up to 50% (Mellino et al., 2015).

In the design and comparison of alternative methods of sewage sludge treatment to find the best solution based on economic and environmental criteria. Compared to other stabilizing methods, anaerobic digestion which offers more effective reduction of the main environmental parameters of sludge, and alkaline thermal hydrolysis and oxidation with hydrogen peroxide which reduce the sludge volume both indicated a low total cost. Wet-air oxidation significantly reduces the sludge, but entails a very high total cost, while making use of incineration for further thermal treatment achieves a large volume reduction in the volume of the final sludge for disposal, nevertheless, it largely increases the total cost (Kordoutis and Rigas, 2005)

Treatment of cow dung by electrical drying requires power supply and hence it is expensive. It is speculated that sand drying beds could be a better alternative since it requires natural factors such as solar radiation for heating and subsequent evaporation and seepage losses through drains. However, the conventional method of drying sewage sludge is by use of sand drying bed in which drying is achieved by natural factors such as evaporation from the sludge through solar radiation and seepage losses through a system of underdrains, and this makes drying inexpensive since electrical energy is not required. On the other hand, cow dung is conventionally dried using rotary drier which requires electrical power supply and often very expensive to handle. Therefore, this study investigated the effectiveness of drying cow dung using sand drying bed in order to save costs because of its dependence on natural factors such as dewatering through evaporation and seepage losses. Outcome from this study can be reasonably justified if sewage sludge and cow dung with similar characteristics are dewatered under the same condition and their results compared. If the dewatering capacity of cow dung is close to the dewatering capacity of sewage sludge, it can be inferred that sand drying bed can serve as better alternative to rotary drier meant for drying cow dung. When reverse is the case, it is not advisable to dry cow dung with sand drying bed. Results from this study would enable waste managers to make decision as in whether it is expedient to replace the conventional electrical heating systems of rotary drier used in drying cow dung with sand drying beds in the drying of cow dung. Therefore, the aim of this study was to investigate the effectiveness of drying cow dung in sand drying bed

2. MATERIALS AND METHOD

2.1 Sample Collection

The samples for this study were cow dung and sewage sludge. The cow dung was collected from a stanchion barn near an abattoir which situate at Onitsha Main market in Anambra state of Nigeria. The cow dung sample was collected with kitchen spoon from the floor of the stanchion barn, placed inside 8 buckets of 20 liters capacity each and transported to the premises where evaporation and seepage experiments were conducted. In a similar manner, sewage sludge was collected from a septic tank behind Seat of Wisdom Library at Abatete in Idemili North local government area of Anambra state, Nigeria. The content in the septic was thoroughly mix with a long stick that was able to reach the base of the tank. Subsequently, a plastic plate was used for collection of sewage sludge which was placed inside 8 buckets of 20 liters capacity each and transported to the premises where evaporation and seepage experiments were carried out. Evaporation and seepage experiments were conducted on both samples simultaneously under the same exposure conditions for effective comparison. Consistency analyses were carried out in order to make the two samples have the same characteristics since they came from different sources and with different initial moisture contents.

2.2 Experimental Set-up and Procedures

Known quantities of samples of sewage sludge and cow dung were oven-dried at a temperature of 105℃ to determine the initial moisture contents of the samples in accordance with BS 1377 (1975). Consistency analysis was carried out to make the two samples have the same initial condition as shown below before introduction into drying beds. The drying bed is a simple sand and gravel filters on which batch loads of sludge are dewatered. At the bottom of the sand drying bed was placed the gravel layer with particle sizes of diameter in the range of 7 – 15 mm of 200 mm thickness. On top of the gravel layer is the sand layer of grain sizes ranging from 0.2 – 0.6 mm which has a 200 mm thickness. The final layer is the sewage sludge and cow dung each of 300 mm thick. The dimensions of model drying bed are 1000 mm long, 300 mm wide and 800 mm overall depth. The underdrain is a 50 mm diameter drainpipe through which seepage water that drain from the sand bed is collected, with provision of a 50 mm overboard. Sewage sludge and cow dung were simultaneously applied on the beds intermittently and the discharges were collected on daily basis. Evaporation from the bed were measured with Pitches atmometer which were placed inside the 300 mm wide and 1000 mm long drying beds, partially covered with polyethylene bag in order to permit solar radiation into the sand drying bed for drying to effectively take place. Schematic diagram for seepage and evaporation losses in drying beds of sewage sludge and cow dung is shown in figure 1.

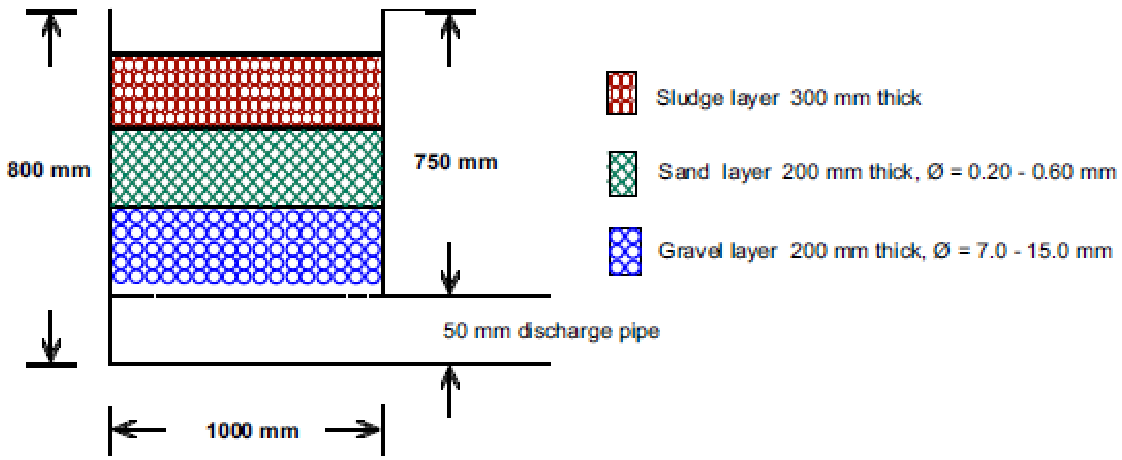

Fig. 1: Schematic diagram of sand drying bed

2.2 Consistency Analysis

Consistency analysis was the first operation carried out prior to seepage and evaporation experiments. A comparison was made between dewaterability in sewage sludge and cow dung. These sludges have different sources, and of course different moisture contents and therefore must be made to have the same initial conditions for effective comparison since the objective of this study was to investigate the effectiveness of dewatering of cow dung using sand drying beds viz;

Weight of cow dung used in the experiment = 45.00kg

Moisture content = 74.07%

Percent solid = 100 – 74.07 = 25.73%

For 45.00 kg cow dung, solid content will be $\frac{25.73}{100} \times 45 = 11.58$

Water content = 45 – 11.58 = 33.42kg

Equivalent 45 kg of sewage sludge based on 81.01% moisture content will contain

100 – 81.01 = 18.99% solid.

45kg of sewage sludge will contain $\frac{18.99}{100} \times 45 = 8.55$ solid content less than 11.58kg for cow dung.

Water content = 45 – 8.55 = 36.45 kg of water.

Since cow dung contains 11.58kg of solid, sewage sludge should contain equal amount of solid for effective comparison. Therefore, equivalent weight of sewage sludge that will contain 11.58kg solid will be viz;

45 kg of sewage sludge contains 36.45kg of water

11.58kg of sewage sludge will contain $\frac{11.58}{8.55} \times 36.45 = 49.37$ kg of water

Weight of sewage sludge = weight of solid + weight of water

∴ weight of sewage sludge = 49.37 + 11.58 = 60.95kg

For cow dung, add 80.00kg of water

Total water content in cow dung = 33.42 + 80.00 = 113.42kg

For sewage sludge, 49.37 – 33.42 = 15.95 kg excess water when compared with water content in cow dung.

Therefore, 80 – 15.95 = 64.05 kg of water to be added to sewage sludge for both samples to have the same initial condition.

Results for consistency analysis is presented in Table 1. The essence of this analysis is to make the two samples have the same characteristics before comparison because they came from two different sources, and of course different initial moisture contents. By this analysis, it can be seen that both samples have equal amounts of solid contents of 11.58 kg and water contents of 113.42 kg each making a total weight of 125.00 kg for both cow dung and sewage sludge respectively.

Table 1: Results from consistency analysis

Sample	Solid content(kg)	Water content (kg)	Quantity of water added (kg)	Total quantity of water in sample (kg)	Grand total weight of sample (kg)
Sewage sludge	11.58	49.37	64.05	113.42	125.00
Cow dung	11.58	33.42	80.00	113.42	125.00

3. RESULTS AND DISCUSSION

3.1 Moisture Content Tests

Moisture contest test was performed in accordance with BS1377(1975). The essence of moisture content test was to determine the initial moisture contents of sewage sludge and cow dung samples. Results obtained will be used to carry out consistency analysis in order to bring the two samples to the same initial conditions for effective comparison and reasonable inference, decision and conclusion that are not misleading. Results of moisture content tests are presented in Table 2.

Table 2: Moisture contents of sewage sludge and cow dung

Sample	Wt. of can(g)	Wt. of can + wet sample(g)	Wt. of wet sample(g)	Wt. of dry sample(g)	Wt. of water (g)	Moisture content (%)
Sewage sludge	18.5242	20.5397	2.0155	0.3827	1.6328	81.01
Cow dung	17.6926	19.6939	2.0013	0.5189	1.4824	74.07

The relationship between seepage and time is shown in figure 1, and it can be seen that the rate at which seepage is taking place is faster in cow dung than in sewage sludge. Seepage stopped after 7 days in cow dung but continued up to 13 days in sewage sludge showing that sewage sludge has higher potential to retain water. It was observed that seepage in cow dung was very high at the initial stage and stopped abruptly after the seventh day while in sewage sludge it was gradual from inception to the end of thirteenth day. Referring to Table 3, dewatering ratio between sewage sludge and cow dung on short term period of dewatering after 7 days was 0.821.

It was observed that seepage stopped after 7 days in cow dung and stopped after 13 days in sewage sludge, so that dewatering ratio between these two sludges at their terminal points of discharge was 1.03. These results indicate that cow dung dewater faster through seepage losses than sewage sludge on short term period by 17.92%, but on long term period, sewage sludge experienced higher dewatering capacity though by a little margin of 2.99%.

Table 3: Results of seepage and evaporation losses from sand drying beds

Parameter	Sewage sludge	% water	Cow dung	% water	Dewatering ratio	% Difference
Initial water content (m^3)	0.113420	100.00	0.113420	100.00	NA	NA
Cumulative water loss from seepage after 7 days	0.049362	43.52	0.060142	50.03	0.821	17.92
Cumulative water loss from seepage on holistic basis (m^3)	0.061998	54.66	0.060142	50.03	1.030	2.99
Cumulative water loss from evaporation (m^3)	0.001011	0.89	0.001041	0.92	0.970	2.88
Final moisture content (m^3)	0.050411	44.45	0.052237	46.06	0.965	3.496
Moisture loss (m^3)	0.063009	55.55	0.061183	53.94	NA	NA
Per cent moisture loss (%)	55.55		53.94		NA	NA

NA – Not applicable

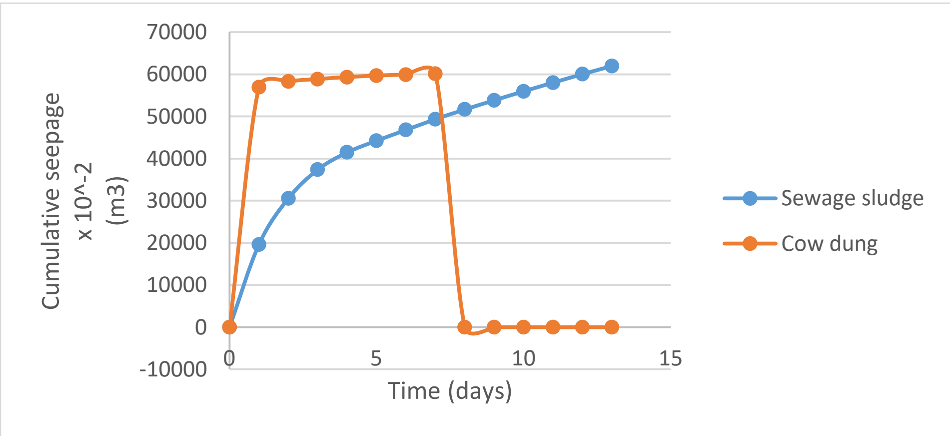

Fig. 1: Relationship between cumulative seepage and time

Results from figure 2 show that evaporation is higher in cow dung with cumulative evaporation of 0.001041 m^3, while in sewage sludge, cumulative evaporation was 0.001011 m^3 with 2.88% difference. However, final moisture content for both sewage sludge and cow dung were 44.45% and 46.06% respectively as shown in Table 3, an indication that moisture loss is higher in sewage sludge than in cow dung by 3.496% which is insignificant. In Table 3, overall moisture loss in sewage sludge was 55.55%, while (Swanwick, J.D. 1972; WPCF, 1959; Ruiz et al., 2010) achieved a moisture loss of between 70 to 84% using the conventional sand drying bed (SDB). In cow dung, overall moisture loss was found to be 53.94%, while Chen et al. (2017) achieved a moisture loss that increased significantly from 70% and above, a result similar to (Swanwick, J.D. 1972; WPCF, 1959; Ruiz et al., 2010). These results evidenced that cow dung can be treated in sand beds since 53.94% of water was removed after 13 days of drying.

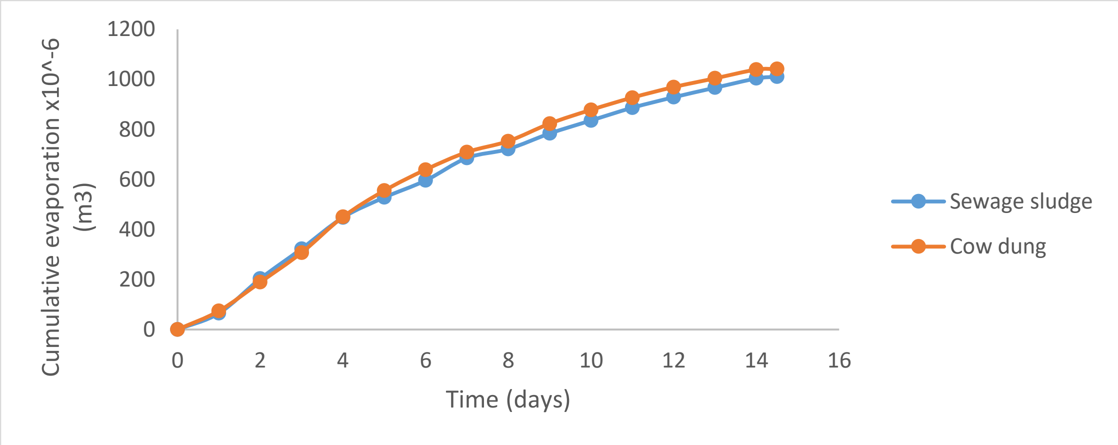

Fig. 2: Relationship between cumulative evaporation and time

4. CONCLUSION

This study investigated the effectiveness of drying cow dung and sewage sludge wastes in sand drying beds. Conventional method of drying sewage sludge is by the use of sand drying bed which depends on natural factors such solar radiation for heating and subsequent loss of moisture via evaporation and seepage through a system of underdrains, while the conventional method of drying cow dung is by the use of rotary dryer but often expensive because it requires electrical energy.

The essence of this study is to investigate the feasibility of using sand drying bed as an alternative to rotary dryer for drying of cow dung. It is concluded that sand drying bed is a better alternative because, dewatering ratio between sewage sludge and cow dung on short term period of dewatering after 7 days was 0.821. Dewatering ratio between these two sludges at their terminal points of discharge was 1.03, and cow dung dewater faster through seepage losses than sewage sludge on short term period by 17.92%, but on long term period, sewage sludge experienced higher dewatering capacity through seepage losses, though by a little margin of 2.99%, while cow dung encountered higher dewatering capacity by a little margin of 2.88%. Overall moisture loss in sewage sludge and cow dung were found to be 55.55% and 53.94% respectively, an indication that cow dung can be effectively dried in sand drying bed that is meant for drying of sewage sludge only.

Conflict of Interest

There is no conflict of interest associated with this work.

REFERENCES

Adeshiyan, R.A., Ajamu, S.O. and Oluremi, J.R. (2010). Management of wastewater from slaughterhouses: An overview, *2nd Annual Civil Engineering Conference on Sustainable Urban Water Supply in Developing Countries. University of Ilorin, Nigeria*, 26th – 28th July, 2010, pp. 123-131.

Agunwamba, J.C. (2001). Waste engineering and management tools, *Immaculate Publications Ltd., Enugu*, pp. 185.

British Standard 1377(1975). Method of tests for soils for civil engineering purposes. *British Standards Institution, 2 Park Street, London*.

Cao, H., Xin, Y. and Yuan, Q. (2016). Prediction of biochar yield from cattle manure pyrolysis via least squares support vector machine intelligent approach. Bioresour. Technol., 202: 158-164.

Chen, G.W., Lin, W.W., and Lee, D.J. (1996). Capillary suction time (CST) as a measure of sludge dewaterability. *Water Science and Technology*, 34(3-4): 443-448.

Chen, X., Qu, Guangfei, Liu, S., Xie, R. and He, Y. (2017). Study on rapid bio-drying technology of cow dung with CaO_2. International symposium on resource exploration and environmental science, IOP Conf. series. *Earth and Environmental Science*, 64: 012112. doi: 10.1088/1755-1315/64/1/012112

Duenser, H. (1996). Sewage sludge utilization at ARA Dornbirn. Experiments-comparisons-evaluations-results. *Umwelt-Technologie Aktuell*, 7, 124.

FAO (1990). Strategies for sustainable animal agriculture development countries. *FAO, Rome*, pp. 7-39.

Jantet, P., Paul, E. and Clauss, F. (1996). Upgrading performance of an activated sludge process through addition of talqueous powders. *Water Science and Technology*, 34(5-6): 75-83.

Kajoie, C.A., Layton, A.C., Gregory, I.R., Sayler, G.S., Taylor, D.E. and Meyers, A.J. (2000). Zooleal clusters and sludge dewatering potential in an industrial activated sludge wastewater treatment plant. *Water Environment Research*, 72(1): 56-64.

Kordoutis, K. and Rigas, F. (2005). Municipal sewage sludge treatment alternative technologies: Economic and environmental evaluation. IASME Transactions, Issue, Vol. 2, 496-504

Mellino, S., Protano, G., Buonocore, E., De Angelis, G., Liu, G., Xu, L. and Ulgiati, S. (2015). Alternative options for sewage sludge treatment and process improvement through circular patterns: LCA-based case study and scenarios. *Journal of Environmental Accounting and Management*, 3(1): 77-85

Misselbrook, T.H., Smith, K.A., Johnson, R.A. and Paina, B.F. (2002). Slurry application techniques to reduce ammonia emissions: Results of some UK Field-scale experiments. *Biosystems Engineering*, 81: 313-321.

Morse, D. (1995). Environmental conditions of livestock producers. Journal of Animal Science, 73: 2733-2740.

Obianyo, J.I. and Agunwamba, J.C. (2015). Modeling of seepage losses in sewage sludge drying bed. *Nigerian Journal of Technology*, 34(1): 63-71.

Olaoye, R.A., Ajamu, S.O., Oluremi, J.R. and Moyofola, V.O. (2018). Sustainable management of cow dung from slaughterhouses. *LAUTECH Journal of Engineering and Technology*, 12(1): 36-42.

Oyeleke, S.B., Onibagjo, H.O. and Ibrahim, K. (2003). Degradation of animal wastes (cattle dung) to produce methane (cooking gas). *Proceedings of the 5th Annual Conference of Animal Science of Nigeria (SAN)*: 168-169

Robinson, J. & Knocke, W.R. (1994). Use of dilatometric and drying techniques for assessing sludge dewatering characteristics. Water Environment Research, 64(1): 60-68.

Smith, J.K. and Vesilind, P.A. (1995). Dilatometric measurement of bound water in wastewater sludge. *Water Research*, 29(12): 2621-2626.

Smith, K.A. and Williams, A.G. (2016). Production and management of cattle manure in the UK and implications for land application practice. *Soil Management*, 32: 73-82

Spinosa, L. (2001). Evolution of sewage sludge regulations in Europe. *Water Science and Technology,* 44(10): 1-8.

Swanwick, J.D. (1972). Second European sewage and refuse symposium

WPCF (1959). Sewage treatment plant design. *(WPCF manual of practice No. 8, ASCE Manual of Engineering Practice,* No. 36*).* https://www.amazon.com/Sewage-Treatment-Design-Practice-Engineering/dp/B008ARBTCI

Ruiz, T., Kaosol, T. and Wisniewski, C. (2010). Dewatering of urban residual sludges: Filterability and hydrotextural characteristics of conditioned sludges, *Separation and Purification Technology,* 72(3): 275-281 https://www.sciencedirect.com/science/article/pii/S1383586610000778?via%3Dihub