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# LEACHING CHARACTERISTICS OF POULTRY LITTER IN FIRST PHASE OF MULTISTAGE ANAEROBIC DIGESTION

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**Abstract**

Poultry litter is highly biodegradable in nature. Therefore, it could be subjected to biomethanation to produce valuable biogas and bio-manure as byproducts. Some studies have been conducted along these lines in India by utilizing the poultry litter as a substrate in batch type dung digesters of KVIC and DENABANDHU models. However, these reactors have the drawbacks of high residence time (30 – 35 days), scum formation problems etc. Moreover, these batch type plants are not suitable for the treatment of large quantities of solid waste. Multistage anaerobic digestion has the potential to overcome some of the aforesaid issues. Anaerobic leaching experiments were conducted at different total solids concentration and pH using poultry litter in order to evaluate the leachate quality for a period of 7 days. The increase in Total solids (TS) % from 15 to 20% show inverse effect on VFA and Alkalinity. The change in pH from 8.5 to 5.5 didn't show much impact on VFA but there is a small impact on alkalinity. It was also observed that the leaching of the organic matter in the solid to the liquid phase is very fast and it is taking place approximately in three to four days and subsequently leachate getting saturated. Therefore, reactor set up was made in the last phase to regularly remove the water from the reactor so that higher driving force is available for leaching. The study resulted in leaching of maximum organic content in the solid to liquid within three days.

Key words: Poultry litter, anaerobic digestion, biogas, VFA, leaching

## Introduction

Poultry manure is rich in organic and inorganic matter. Manure composition varies with the type of feed and bird. It contains nitrogen (1.22 – 1.63%), phosphorus (0.89 – 1.04%), potassium (1.34 – 1.7) and also many micronutrients such as zinc, copper, iron and selenium (Bishnoi and Bajwa, 1994). Poultry manure is used in livestock feeds to lower the feed cost but may be discouraged due to potential source of pathogenic microorganisms such as salmonella. In India, poultry manure is mainly utilized for growing crops and to lesser extent for fish production. Excess use of poultry manure may result in air land and water pollution apart from

spreading pathogenic organisms like salmonella, *E.coli* (Aili et al., 1991). Poultry industry uses a great deal of inorganic source of phosphorus in both layer and broiler diets. Nitrogen and phosphorus from poultry manure may pose problem of acceleration of eutrophication, which is unnatural in fish water system (Bishnoi and Bajwa, 1994 and Roland et al., 1993). Poultry manure depletes the dissolved oxygen in the water resulting in poor performance of fish. European countries have already restricted the amount of animal waste application to land.

Approximately one million tons of poultry litter is produced in India annually. This waste contains inorganic solids having fertilizer value and biodegradable organic matter. Indiscriminate dumping of poultry litter around poultry farms is very common in India. Poultry industry ranks as one of the biggest in the organized sector in India with an annual growth rate of 10-12% and has achieved the $5^{th}$ position in world egg output and $19^{th}$ in world broiler production. The state of Andhra Pradesh is placed first in India in poultry production. An adult hen produces 14 kg of egg mass and about 40 kg of excreta in a year. Poultry excreta are available as deep litter from litter-reared birds and as cage manure from cage-reared birds. The litter causes problems of fly/insect menace, offensive odour particularly at high humid areas due to the high moisture content (70-80%) of poultry excreta. A majority of the poultry farms located in and around urban areas prefer cage rearing. Cage manure is available to an extent of 1 million tons per annum in India (Hakeem et al. 2003).

Poultry manure can be treated by aerobic and anaerobic methods for degradation of the organic matter. It is unsuitable for compost making due to its high moisture and furthermore can lead to ammonia emission and environmental pollution. Utilization of poultry manure for biogas generation will not only improve sanitation in and around poultry farms but also provide rich organic manure for fishponds and crops. Poultry manure is rich in nitrogen and carbon compared to cattle dung. There are reports that poultry manure generates more biogas compared to cattle dung (Rajashekhar and Mohankumar, 1994) and thus there is a great potential for generating biogas from poultry manure. There are certain limitations in using poultry manure for biogas generation (Rajashekhar et al., 1996). Poultry manure is viscous in nature with high calcium content and sand/grit. Feathers pose a problem and hence require pre treatment.

In China, a two-stage process (Aili et al., 1991) was developed for the treatment of chicken manure. However, application of the above process for higher scale operation is not known. The high rate digesters for solid waste treatment are basically part of the multistage two-phase anaerobic system. Here, the three stages of anaerobic digestion, namely, hydrolytic, acetogenic, and methanogenic steps are carried out in separate reactors (Kim et al., 2000, Ghosh et al., 2000, Rao et al., 2008 and 2011). The organic solid waste is first subjected to hydrolysis and acetogenesis in reactors to produce a liquid phase rich in volatile fatty acids. Approximately 4000 to 5000 mg/l of volatile fatty acids are produced at a hydraulic retention time (HRT) of 2-4 days. The solids fraction after the digestion is pressed and liquid portion is mixed with the volatile fatty acid (VFA) fraction. The digested solids are removed from the bottom of the hydraulic reactors, dried and used as soil conditioner or organic manure. The final step of biomethanation, namely, methanogenesis is carried out in high rate digesters such as Up-flow

Anaerobic Sludge Blanket (UASB) reactor, Expanded Granular Sludge Bed reactor (EGSB), Fixed Film reactor, or Fluidized Bed reactor. The liquid fraction is subjected to methanogenic fermentation to produce methane in the high rate methanogenic reactors. The present work is aimed at generating organic liquid leachate from poultry litter that is available in solid or semi-solid farm and study the effect of Total solids (TS) and pH on leaching.

**Materials and Methods**

Poultry litter was collected from the Live Stock Research station of Sri Venkateswara Veterinary University (SVVU), Rajendranagar, Hyderabad, Andhra Pradesh, India in sundried conditions. The litter was brought to work place as per requirement and stored in dry condition. Poultry litter slurry was prepared from the same storage and fed to the digester everyday as per requirement. The experimental set up consisted of 5litre anaerobic conical flasks and biogas vent through water reservoir as shown in Fig.1. Initially, fresh poultry droppings were characterized for pH, Total solids (TS), Volatile solids (VS), Fixed solids (FS), Total Kjeldahl nitrogen (TKN), Ammonical nitrogen (NH4- N) and Organic nitrogen.

**Figure 1. Anaerobic batch reactors with gas collection**

Five batch reactors were studied by varying total solids from 15 to 20% (Table 1). Two reactors were fed with 15% solids and remaining three reactors were fed with 20% solids. The pH of 5.5 was maintained in two reactors and remaining three reactors were kept at original pH of 8.5. After feeding the reactor with poultry litter, the reactors were kept under anaerobic conditions for ten days. Every day sample was taken from each reactor and analyzed for VFA and Alkalinity. In the digester-6, everyday total slurry was drained from the digester and filtered. The solids are returned to digester and filtrate was discarded. The same quantity of water added to the digester.

**Table 1. Experimental operating conditions used for anaerobic leaching of poultry litter**

| Digester | Type | pH | TS, % |
|---|---|---|---|
| 1 | Batch | 8.5 | 20 |
| 2 | Batch | 5.5 | 20 |
| 3 | Batch | 5.5 | 15 |
| 4 | Batch | 8.5 | 15 |
| 5 | Batch | 8.5 | 20 |
| 6 | Semi- Batch | 8.5 | 20 |

## Results and Discussion

*Characterization of poultry litter*

Characterization of poultry litter was tabulated in Table 2. The composition of both litter and manure is predominantly water and carbon (C) with smaller amounts of nitrogen (N) and phosphorous (P) and trace levels of chlorine (Cl), calcium (Ca), magnesium (Mg), sodium (Na), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn) and arsenic (As). During the production cycle accumulating manure is mixed with litter and at the end of the cycle both are removed together. Nitrogen exists in several forms and is constantly transformed by microbial activity, and changes in temperature, pH, moisture, and oxygen concentration. The concentration of ammonia nitrogen is important when considering any of the disposal techniques. Poultry manure contains significant concentrations of organic nitrogen due to the presence of high levels of protein and amino acids. Of the nitrogen in fresh manure, 60–80% is typically in organic form, such as urea and protein. Depending on environmental conditions a large percentage of this organic nitrogen (40–90%) is converted to ammonia within a year. Ammonia exists as either gas ($NH_3$) or in an ionized state $NH^+_4$, which is water-soluble. $NH_3$ gas can be lost to the atmosphere while $NH^+_4$ can be transformed by microorganisms to nitrate (a process known as nitrification). During

**Table 2. Physiochemical characteristic of poultry litter (Original litter diluted to 20% solids)**

| S.No | Parameter | mg/l |
|---|---|---|
| 1 | Sulfate | 975-1425 |
| 2 | Inorganic phosphorous | 100 |
| 3 | Sodium | 196 |
| 4 | Potassium | 390 |
| 5 | COD | 20000-34000 |
| 6 | TS (dry%) | 98% |
| 7 | VS (dry%) | 73% |
| 8 | FS (dry%) | 27% |
| 9 | Moisture content (original sample) | 2% |
| 10 | VS | 95% |
| 11 | FS | 5% |

anaerobic digestion of poultry manure the concentration of endogenous ammonia-nitrogen rises considerably. While some members of an anaerobic microorganism population can use ammonium ions, an excess of ammonium can inhibit the destruction of organic compounds, the production of volatile fatty acids, and methanogenesis (Krylova et al., 1997). The presence of ammonium ions also contributes to a corrosively high pH and leads to handling, storage and disposal problems. The minimization of ammonia content is desirable for any treatment of poultry litter.

**Leaching Behavior**

In first three batch digesters, VFA start with high values and decreased little and stabilized after day 3. Whereas alkalinity starts with low or zero and increased until day 3 and after that it was stabilized. The increase in Total solids (TS) % from 15 to 20% show inverse effect on VFA and Alkalinity as shown in figure 2 i.e. Batch 2 and Batch 3. The change in pH from 8.5 to 5.5 didn't show much impact on VFA but there is a small impact on alkalinity as we saw in figure 1 i.e. Batch 1 and Batch 2. Compared all these three digesters, Batch digester 4 behaved differently and it was understood from this experiment that the water is getting saturated in terms of VFA if the litter is kept for above three days in a reactor. The leaching of the organic matter in the solid to the liquid phase is very fast and it is taking place approximately in three to four days in the first instance and subsequently the leachate is getting saturated. The semi batch experiments resulted in leaching of maximum organic content in three days as shown in figure 3. Subsequently available organic content was very less in the solid matter.

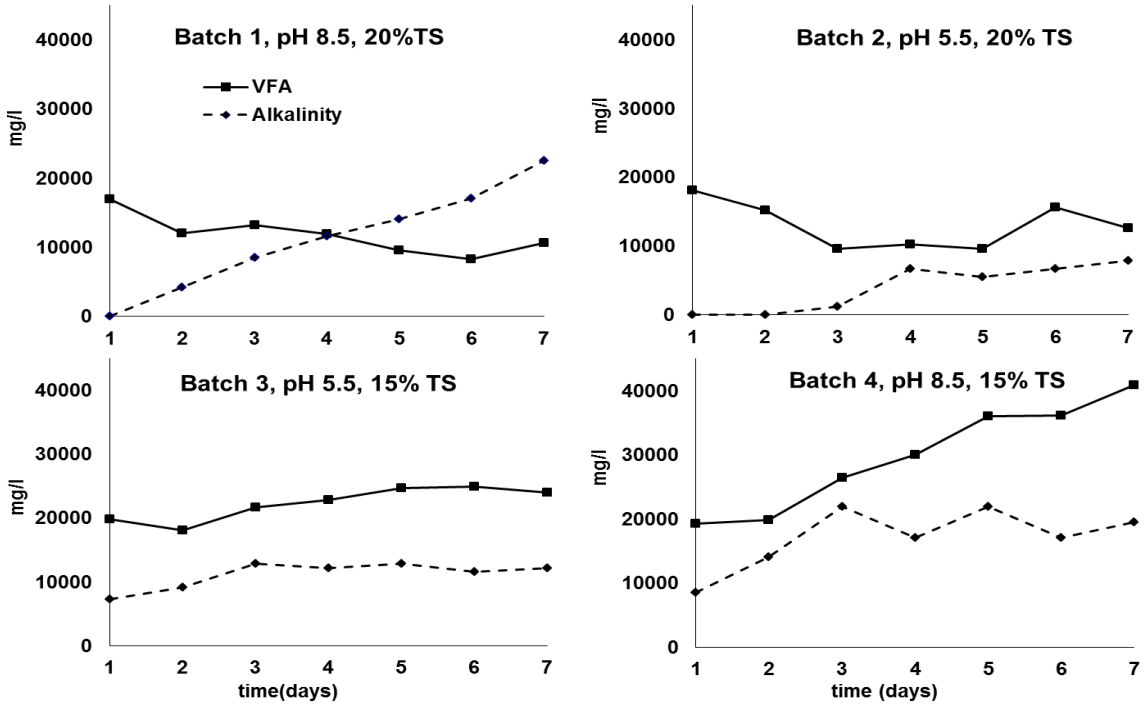


**Figure 2. VFA and alkalinity for all 4 batch digesters over time**

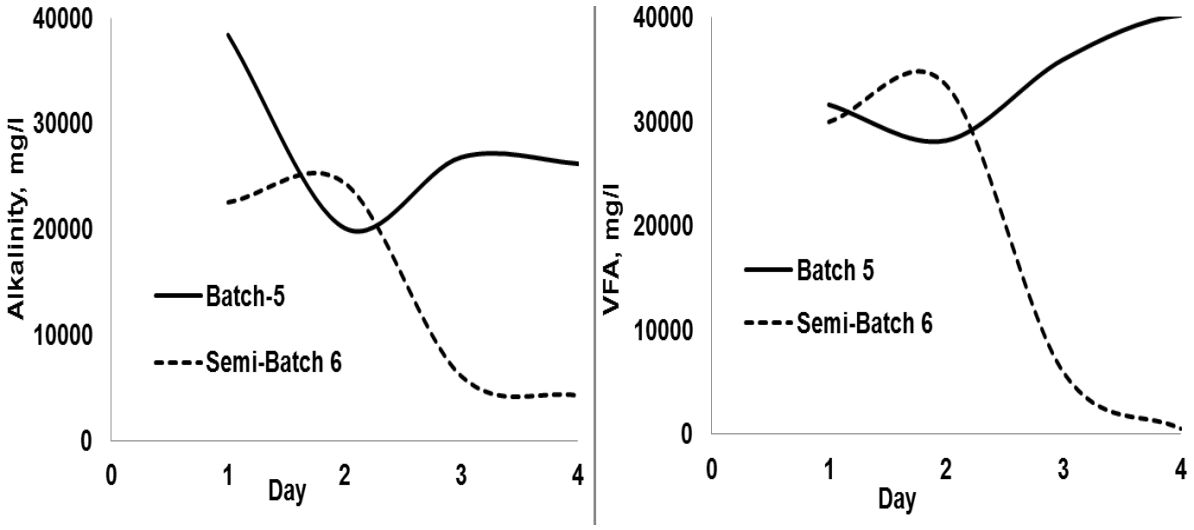


**Figure 3. Comparison between batch digester 5 and semi-batch digester 6 for VFA and alkalinity**

## Conclusion

The litter contains high organic matter and inorganic matter. The inorganic matter is mainly nitrogen, calcium, phosphorus etc. that are main constituents of feed to poultry. The organic matter is highly biodegradable. The water is getting saturated in terms of VFA if the litter is kept for above four days in a reactor. The leaching of the organic matter in the solid to the liquid phase is very fast and it is taking place approximately in three to four days in the first instance and subsequently the leachate is getting saturated. Therefore, reactor set up was made in the last phase to regularly remove the water from the reactor so that higher driving force is available for leaching. The above experiments resulted in leaching of maximum organic content in three days. Subsequently available organic content was very less in the remaining solid matter. The increase in Total solids (TS) % from 15 to 20% show inverse effect on VFA and Alkalinity. The change in pH from 8.5 to 5.5 didn't show much impact on VFA but there is a small impact on alkalinity. Further experiments are required to consolidate the above results.

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