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FACTORS AFFECTING ENVIRONMENTAL POLLUTION OF FARM ANIMALS MANURE

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SUMMARY

This experiment was designed to study the effect of animal species, bedding materials and storage periods on environmental pollution of farm animals' manure. Manure samples of different animal species (buffaloes, Baladi cattle, sheep, goats, camels, horses and donkeys) collected from El-Raheb farm were used and mixed with different bedding materials (sand, straw, sawdust and newspaper) in wide plates and were left at room temperature for 28 days. The physical, chemical and biological analyses were determined at 1st, 2nd, 3rd, 7th, 14th and 28th day.

All physical (color, odor, moisture and pH), chemical (N%, P% and K%) and biological characteristics (total coli forms count) were significantly affected by different types of bedding materials. Color was not affected by storage period. On the other hand, odor, moisture and pH were decreased significantly by storage period. Also, the same result was obtained for N%. However, P% and K% were not significantly affected by storage period. Total coli forms count were significantly affected by storage period. Manure had the highest (P<0.01) coli forms count during the first three days of storage then started in reduction from 7th and 14th days to touch bottom at day 28.

Keywords: Environmental pollution, Bedding materials, Storage period, Farm animal manure

INTRODUCTION

Large concentrations of animals in relatively small areas create difficult challenges in terms of odor and nutrient management (Satter *et al*., 2002). On the other hand, livestock wastes can provide valuable organic material and nutrients for crop and pasture growth. However, nutrients contained in animal manure (a mixture of animal's feces, urine and bedding materials) can degrade water quality if they are over-applied to land and enter water resources through runoff or leaching (Ribaudo *et al*., 2004). High loading rates of sediment, nitrogen (N), phosphorous (P), and pathogens to soils and waters can occur from animal operations (Hubbard *et al*., 2004). Animal waste, if not properly managed, can be transported by water over the surface of agricultural land to nearby lakes and streams. There, the nutrients in animal waste can reduce the oxygen content of the water, leading to algae blooms, fish kills, and threats to other wildlife. Solids deposited in water bodies can accelerate eutrophication by releasing nutrients over extended periods. Leaching from manure storage lagoons and percolation through the soil of fields sprayed with animal waste has resulted in nutrient contamination of groundwater resources (Copeland and Zinn, 1998).

Microorganisms associated with manure may present a significant risk to health. The population of several known pathogens may be quite high in manure. Runoff from land application sites may carry large numbers of organisms into streams. Recreational use of the streams may then bring people into direct exposure to large numbers of potentially pathogenic microorganisms. Several disease outbreaks have been associated with manure contamination of water or food that has been contacted by manure (USEPA, 2004). *Coli* forms bacteria may not cause disease, but may indicate the presence of pathogenic organisms. These organisms may cause: intestinal infections, dysentery, hepatitis, typhoid fever, and cholera in humans (Fleming and Ford, 2001).

Cole *et al*. (2005) reported that nutrient content of manure from dairy cattle is affected by a variety of factors, many of which are related to a specific farming operation. Some of these factors include method of storage, type of manure application system, housing and bedding system, diet of the cattle and environmental temperature. All of these factors affect the amounts of nitrogen (N), phosphorus (P), potassium (K) and micronutrients in the manure.

The objectives of this study were to evaluate some factors affecting manure pollution and how to reduce the harmful effects of farm animal manure on environmental pollution by using some available bedding materials throughout different storage periods.

MATERIALS AND METHODS

In vitro experiment was designed to study the effect of animal species, bedding materials and storage periods on environmental pollution of farm animal manure. Manure samples (n=630) of different animal species (buffaloes, Baladi cattle, sheep, goats, camels, horses and donkeys) collected from El-Raheb farm (which belonging to the Animal Production Department, Faculty of Agriculture, Minoufiya University, Shebin El-Kom, Egypt) were used and mixed with different bedding materials (sand, straw, sawdust and newspaper) throughout different storage periods extended for 1, 2, 3, 7, 14 and 28 days after manure collection.

Manure samples of each animal species were placed in wide five plastic plates. The 1st plate contained only raw manure as a control sample. 2nd, 3rd, 4th and 5th plates contained raw manure mixed with sand, straw, sawdust and finally with newspaper. All plates were left at room temperature for 28 day. The physical, chemical and biological analyses were determined at 1st, 2nd, 3rd, 7th, 14th and 28th day.

Twenty six persons were shared in human panel test which conducted to measure and quantify manure samples color grade and odor intensity. Manure color grades used in panel sheet were Brown-Olive, Dark-Green and Yellow-Olive. Human assessors estimate the odor intensity by sniffing the manure samples and choice one odor category from the three categories in panel sheet (offensive, faint or strong).

The recommended methods of manure analysis by Peters *et al*. (2003) were used to determine manure moisture, pH, N, P and K.

Manure bacterial populations were evaluated by weighing 10 g of manure sample into 90 ml of sterile PBS at pH 7.2 in sterile bags, then mixing for one min. A serial dilution of 1:10 was aspirated with one ml of solution into nine ml of sterile PBS per tube. Each dilution starting at 1×10^3 to 1×10^7 was plated in each of two duplicate plates on the surface of the medium. MacCkonkey agar spread plates were incubated at 37°C for 24 h , after which colony forming units were counted and recorded as (colony-forming unit (cfu) Log10/g manure) of fresh weight (Panivivat *et al*., 2004).

Statistical analyses were conducted using General Liner Model (GLM) procedure of SPSS (2001). Duncan's new multiple range test was used to compare means. The following model was used:

$$Y_{ijkl} = \mu + A_i + B_j + S_k + e_{ijkl}$$

Where:

Y_{ijkl} = The environmental pollution of farm animal manure

μ = general mean.

A_i = The fixed effect of the i^{th} animal species, (i = 1, 2, 3, 4, 5, 6, 7).

B_j = The fixed effect of the j^{th} bedding materials, (j = 1, 2, 3, 4, 5).

S_k = The fixed effect of the k^{th} storage periods, (k = 1, 2, 3, 4, 5, 6).

e_{ijkl} = *Random residual error.*

RESULTS AND DISCUSSION

Effect of animal species on manure characteristics:

Physical characteristics:

The effects of animal species on manure physical characteristics are shown in Table (1). Goats manure had the highest color score (P<0.01) followed by sheep, donkeys, Baladi cattle and horses manure, while camels and buffaloes manure had the lowest color score. Differences in manure color grades among animal species may be due to physical differences in physiological mechanisms of digestive system and feed type for each animal species. Also, goats manure had the highest odor intensity (P<0.01) followed by sheep, donkeys, horses, Baladi cattle and camels manure, while buffaloes manure had the lowest odor intensity. Higher odor intensity for goats, sheep, donkeys and horses may be due to consistent and compact form of their manure particles and slowing down emission rate. On the other hand, buffaloes, Baladi cattle and camels manure had the highest (P<0.01) moisture percentage followed by goats and sheep manure, while donkeys and horses manure had the lowest moisture percentage. Similar results are obtained by Fontenot *et al*. (1983) who found that sheep waste contains less moisture than waste from dairy and beef cattle due to the differences in the physiological mechanisms for water retention and excretion. In addition, the effect of animal species on manure pH value was highly significant (P<0.01). Buffaloes and Baladi cattle had the lowest pH value, meanwhile sheep and goats manure had the highest pH one. While, pH value for camels, horses and donkeys manure showed intermediate values (Table 1).

Chemical characteristics:

The effects of animal species on manure chemical characteristics are shown in Table (2). Goats manure had the highest (P<0.01) N% followed by sheep, camels, horses, donkeys and Baladi cattle manure, while buffaloes manure had the lowest N%. Likewise, goats manure had the highest (P<0.01) P% followed by sheep, camels, Baladi cattle and donkeys manure. On the other hand, buffaloes and horses manure had the lowest P%. Furthermore, goats and sheep

manure had the highest (P<0.01) K% followed by camels, donkeys and horses manure. In contrast buffaloes and Baladi cattle manure had the lowest K%. The present values of manure N, P and K percentages are in agreement in part with those reported by Vanderholm (1979), ASAE (2003) and Lorimor *et al*. (2004) who reported that manure N, P and K % from sheep were higher than from dairy, beef cattle or horses.

Biological characteristics:

Manure from buffaloes and Baladi cattle had the highest (P<0.01) *coli* forms count followed by manure from goats, sheep, horses and donkeys. On the other side, manure from camels had the lowest *coli* forms count (Table 2). Similar results are found by Hubbard *et al*. (2004).

Effect of using different bedding material on manure characteristics

Physical characteristics

Color score, odor intensity and moisture were the lowest in sand bedding and were the highest in raw manure. While, straw, sawdust and newspaper had intermediate values (Table 3). Similar findings are observed by Misselbrook and Powell (2005), Elaref (2006) and El Kaschab *et al*. (2009). With respect to pH values, straw and sawdust bedding materials had the lowest values followed by newspaper bedding and raw manure. While, the pH value for sand bedding was the highest (Table 3).

Chemical characteristics:

Raw manure had the lowest (P<0.01) N% followed by sand bedding. Meanwhile, N% for sawdust and newspaper bedding were intermediate. In contrast, straw bedding had the highest N%. Concerning the P%, sand bedding was the lowest and raw manure was the highest, whereas the other bedding materials showed intermediate values. In contrast, the highest values of K% were observed by using straw and sand bedding materials and the lowest values were found in raw manure. The intermediate values were obtained by the other materials (Table 4). The present results shows that using some bedding materials lead to increase nitrogen and potassium percentage in manure, these results were in agreement with those observed by Vanderholm (1979) who reported that bedded manure systems tend to minimize nitrogen losses. Chambers *et al*. (2003) reported that presence of bedding material can reduce NH_3 emissions from cattle housing and increase manure N content. They reported that emissions reduction to be 30% lower from a straw-bedded, deep litter cattle housing system than from a slurry-based in free-stall system. Misselbrook and Powell (2005) found that NH_3 emissions over 48 h were significantly less from sand and pine shavings than from chopped newspaper, chopped corn stalks, and recycled manure solids.

Biological characteristics:

Sand bedding material had the lowest (P<0.01) *coli* forms count followed by raw manure, sawdust and newspaper bedding materials, while straw bedding material had the highest *coli* forms count (Table 4). Similar findings are found by Fairchild *et al*. (1982), Zdanowicz *et al*. (2004) , Elaref (2006) and El Kaschab *et al*. (2009), who found that sand had the lowest mean of *coli* forms count followed by straw, newspaper and sawdust, respectively.

Effect of storage period on manure characteristics:

Physical characteristics:

Differences in color score throughout studied storage periods were not significant (Table 5). Manure during the first three days of storage (1, 2 and 3) had the highest (P<0.01) odor intensity then start in reduction from day 7 and 14 to reach the lowest level in day 28. Similar results are obtained by Powers *et al*. (1999) who noticed that fresh manure from dairy cow was less odorous than manure held for three days. Also, odor intensity decreased linearly from fresh manure (0 day) to 20 day stored manure.

Manure moisture percentage was decreased (P<0.01) by the time during storage period (Table 5). Similar results are obtained by Zhu *et al*. (2000) who reported that manure total solids increased by time throughout storage period and moisture decreased. Moreover, manure pH value was decreased significantly (P<0.01) by increasing storage period. (Table 5). Similar findings are observed by Miller *et al*. (2006) who found that pH declined in all incubated fecal slurries, but to different degrees depending upon the diet fed. The same results are obtained by Kunz *et al*. (2009).

Chemical characteristics:

Manure N% was decreased (P<0.01) by increasing the time throughout storage period (Table 6). These results are in agreement with those observed by Vanderholm (1979) who reported that nitrogen is the most sensitive nutrient to volatile losses in the form of ammonia after excretion and during storage in different species of waste systems. Ackerman and Cicek (2010) reported that over half of the total nitrogen can be lost via ammonia (NH_3) volatilization during manure storage. On the other hand, differences in manure phosphorus and potassium percentage were not affected by

storage period. Larney *et al*. (2006) reported that phosphorus is reactive but non-volatile, so changes during storage are between solid and dissolved states and between organic and inorganic forms, but losses of P from a system are usually ascribed to sampling error or leaching.

Biological characteristics:

Storage manure during the first three days (1st, 2nd and 3rd) had the highest (P<0.01) *coli* forms count then start in reduction from the 7th and 14th to reach the lowest level at the 28th (Table 6). These results are in agreement with those obtained by Clemm (1977) who found that there was an initial increase in the number of indicator bacteria in cow feces for the first two weeks, and by the fifth week the bacteria were back to their initial levels. Zdanowicz *et al*. (2004) reported that there were significantly more *coli* forms in sand bedding on 1st, 2nd, and 6th days than on zeros day. Elaref (2006) and El Kaschab *et al*. (2009) found that there were significantly more *coli* forms in sand, straw, sawdust and newspaper bedding on the 1st, 2nd, and 6th days than on zeros.

It could be concluded that using some types of bedding materials (such as sand and straw) lead to reduce environmental pollution of farm animal manure by banding and decreasing release rate of pollutants from manure. Also, manure in open yard was losing some pollutants throughout storage period to surround environment. So, farmers should be selecting a proper manure storage method and bedding materials to prevent environmental pollution of farm animals manure.

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Table 1. Influence of animal species on physical characteristics of manure (Means ± SE) (n=630)

Animal species (n=630)	No.	Color **	Odor **	Moisture% **	pH **
Buffaloes	90	2.39^{e}±0.008	2.26^{d}±0.039	58.51^{a} ±1.08	6.48^{d} ±0.025
Baladi Cattle	90	2.54^{c}±0.011	2.39^{cd}±0.045	56.93^{ab} ±1.04	6.67^{c} ±0.029
Sheep	90	2.66^{b}±0.012	2.66^{b}±0.042	54.62^{b} ±0.97	7.14^{a} ±0.025
Goats	90	2.71^{a}±0.010	2.89^{a}±0.060	54.95^{b} ±0.99	7.10^{a} ±0.022
Camels	90	2.40^{e}±0.011	2.38^{cd}±0.044	56.03^{ab} ±0.93	6.99^{b} ±0.023
Horses	90	2.47^{d}±0.012	2.45^{c}±0.047	48.70^{c} ±0.81	7.01^{b} ±0.024
Donkeys	90	2.65^{b}±0.011	2.47^{c}±0.050	48.89^{c} ±0.78	6.98^{b} ±0.024

Means within the same column with different superscript are significantly different ** = Highly significant

Table 2. Influence of animal species on chemical and biological characteristics of manure (Means ± SE)

Animal species (n=630)	No.	N% **	P% **	K% **	coliforms count cfu Log10/g **
Buffaloes	90	0.446^{f} ±0.004	0.111^{f} ±0.001	0.424^{e} ±0.004	6.75^{a} ±0.106
Baladi Cattle	90	0.462^{e} ±0.004	0.121^{d} ±0.001	0.419^{e} ±0.004	6.69^{a} ±0.099
Sheep	90	0.641^{b} ±0.005	0.168^{b} ±0.001	0.587^{a} ±0.002	6.04^{b} ±0.096
Goats	90	0.690^{a} ±0.005	0.177^{a} ±0.001	0.595^{a} ±0.003	6.06^{b} ±0.100
Camels	90	0.544^{c} ±0.005	0.145^{c} ±0.001	0.537^{b} ±0.003	5.17^{c} ±0.101
Horses	90	0.495^{d} ±0.004	0.112^{f} ±0.001	0.472^{d} ±0.003	6.01^{b} ±0.095
Donkeys	90	0.497^{d} ±0.005	0.114^{e} ±0.001	0.487^{c} ±0.004	5.96^{b} ±0.094

Means within the same column with different superscript are significantly different
** = Highly significant

Table 3. Influence of bedding materials on physical characteristics of manure (Means ± SE)

Bedding materials (n =630)	No.	Color **	Odor **	Moisture% **	pH **
Raw manure	126	2.65^{a} ±0.014	2.85^{a} ±0.057	61.68^{a} ±1.04	6.94^{ab} ±0.029
Sand	126	2.42^{d} ±0.012	2.29^{d} ±0.042	50.13^{c} ±0.72	6.97^{a} ±0.027
Straw	126	2.54^{c} ±0.013	2.74^{ab} ±0.051	52.51^{b} ±0.71	6.87^{b} ±0.029
Sawdust	126	2.53^{c} ±0.012	2.36^{c} ±0.033	52.54^{b} ±0.70	6.86^{b} ±0.030
Newspaper	126	2.58^{b} ±0.011	2.65^{b} ±0.053	52.60^{b} ±0.72	6.91^{ab} ±0.028

Means within the same column with different superscript are significantly different ** = Highly significant

Table 4. Influence of bedding materials on chemical and biological characteristics of manure (Means ± SE)

Bedding materials (n =630)	No.	N% *	P% **	K% **	coliforms count cfu Log10/g *
Raw manure	126	0.524^{c} ±0.009	0.143^{a} ±0.003	0.455^{d} ±0.007	6.06^{b} ±0.094
Sand	126	0.537^{b} ±0.009	0.129^{c} ±0.002	0.532^{a} ±0.005	5.78^{c} ±0.092
Straw	126	0.552^{a} ±0.007	0.134^{bc} ±0.002	0.545^{a} ±0.005	6.28^{a} ±0.094
Sawdust	126	0.542^{ab} ±0.009	0.132^{bc} ±0.002	0.483^{c} ±0.006	6.13^{ab} ±0.095
Newspaper	126	0.542^{ab} ±0.008	0.138^{ab} ±0.002	0.501^{b} ±0.006	6.19^{ab} ±0.094

Means within the same column with different superscript are significantly different
* = Significant ** = Highly significant

Table 5. Influence of storage period on physical characteristics of manure (Means±SE)

Storage period (days) (n =630)	No.	Color NS	Odor **	Moisture% **	pH **
1	105	2.51±0.015	2.86^{a} ±0.064	65.36^{a} ±0.70	7.26^{a} ±0.021
2	105	2.49±0.014	2.87^{a} ±0.047	61.10^{b} ±0.63	7.11^{b} ±0.022
3	105	2.52±0.015	2.80^{a} ±0.049	57.26^{c} ±0.60	6.94^{c} ±0.024
7	105	2.54±0.015	2.52^{b} ±0.047	50.92^{d} ±0.51	6.79^{d} ±0.025
14	105	2.57±0.017	2.29^{c} ±0.043	46.60^{e} ±0.40	6.71^{e} ±0.024
28	105	2.61±0.014	2.13^{d} ±0.041	43.30^{f} ±0.35	6.65^{e} ±0.024

Means within the same column with different superscript are significantly different
NS = Not significant ** = Highly significant

Table 6. Influence of storage period on chemical and biological characteristics of manure (Means±SE)

Storage period (days) (n =630)	No.	N% **	P% NS	K% NS	coliforms count cfu Log10/g **
1	105	0.604^{a} ±0.009	0.138±0.003	0.510±0.006	6.86^{a} ±0.049
2	105	0.577^{b} ±0.009	0.137±0.003	0.507±0.007	6.82^{a} ±0.050
3	105	0.554^{b} ±0.009	0.136±0.003	0.505±0.007	6.76^{a} ±0.052
7	105	0.522^{c} ±0.008	0.135±0.002	0.502±0.007	6.36^{b} ±0.047
14	105	0.497^{d} ±0.008	0.133±0.002	0.499±0.006	5.48^{c} ±0.051
28	105	0.482^{d} ±0.008	0.132±0.003	0.496±0.007	4.32^{d} ±0.046

Means within the same column with different superscript are significantly different
NS = Not significant ** = Highly significant

العوامل المؤثرة على التلوث البيئى لسباخ الحيوانات المزرعية

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1- قسم الإنتاج الحيوانى، كلية الزراعة، جامعة سوهاج، مصر، 2- قسم الإنتاج الحيوانى، كلية الزراعة، جامعة المنوفية، مصر

أجريت هذه التجربة لدراسة تأثير كل من نوع الحيوان ونوع الفرشة ومدة التخزين على التلوث البيئى لسباخ الحيوانات المزرعية. تم جمع عينات سباخ من أنواع حيوانية مختلفة (جاموس – أبقار بلدية – أغنام – ماعز – إبل – خيول – حمير) من مزرعة الراهب التابعة لقسم الإنتاج الحيوانى – كلية الزراعة – جامعة المنوفية، وتم خلط تلك العينات مع فرشات مختلفة (رمل – قش أرز – نشارة خشب – ورق جرائد) فى أطباق متسعة وتركت على درجة حرارة الغرفة لمدة 28 يوم. وتم إجراء التحليلات الطبيعية والكيميائية والبيولوجية على تلك العينات فى اليوم 1، 2، 3، 7، 14، 28.

ويمكن تلخيص النتائج فى أن جميع الخصائص الطبيعية (اللون – الرائحة – الرطوبة – درجة الحموضة) والكيميائية (نسبة النيتروجين والفوسفور والبوتاسيوم) والبيولوجية (عدد الكوليفورم الكلى) تأثرت بصورة معنوية بكل من نوع الحيوان ونوع الفرشة المستخدمة. ولم يتأثر لون السباخ بمدة التخزين بينما إنخفضت درجة الرائحة والرطوبة والحموضة لعينات السباخ بدرجة معنوية مع مرور الوقت، كما لوحظت نفس النتيجة بالنسبة لنسبة النيتروجين، بينما لم تتأثر كل من نسبة الفوسفور ونسبة البوتاسيوم بمدة التخزين. كما تأثر عدد الكوليفورم الكلى بمدة التخزين فكان أعلى مستوى خلال اليوم 1، 2، 3 ثم بدأ فى الإنخفاض فى اليوم 7، 14 إلى أن بلغ أقل مستوى له فى اليوم 28.