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# Extractability of Potassium from Some Organic Manures in Aqueous Medium and the Effect of pH, Time and Concentration

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**ABSTRACT:** The effect of pH, time and concentration on the extractability of potassium from five types of organic manures (cow dung, local chickens, duck and commercial chickens' faeces on bedded and unbedded floor) were studied. Experiments were conducted in water at 40°C. Cumulative extraction curves of potassium resulting from a 2-hour equilibration period indicated an initial fast process, the rate of which slowed down at later extraction numbers. Corresponding curves of extraction of the element as affected by selected factors showed that pH, concentration of the nutrient and equilibration time were important in influencing the readiness with which manures release potassiuim in aqueous medium. Individual character of each of the manures in releasing the element was also exhibited, but in general, the bedded floor commercial birds manures produced the highest rate, while duck and cow dung showed the least. The effect of the bedding material in enhancing the release of the nutrient from these manures is explained in terms of their relatively smaller particle size. The possibility of contribution to the nutrient resource of the manure by the material itself may be an additional factor. @JASEM

There have been greater efforts in recent years to provide research data and information on manures as alternative sources of nutrients in crop production. This interest of agricultural scientists derives from the rising cost and the uncertainty of the availability of commercial fertilizers, a situation that is attributable to the dwindling economic fortunes of many nations. The confidence of farmers, especially the peasant group, in their age-long profession has to be prevented from waning.

Animal and poultry manures contain the basic nutrients required for the growth and enhancement of the yield of vegetables and root crops (Kogbe, 1985; Kwakye, 1980; Sharpley and Smith, 1995; Hemingway, 1961). Yagodin (1984) reported the wide variation in the nutrient content of manures and attributed the phenomenon to the composition of the feed. However, focus has been on the quality of manure and crop performance under their influence (Adeyemo, *et al.*, 1987; Ifenkwe *et al.*, 1992; Titiloye *et al.*, 1986). In comparing the effect of application of organic manures with commercial fertilizers, Djokoto and Stephens (1961) attributed the superior result recorded with the former partly to the slow release of nutrient from its reserve during decomposition and crop growth. Healthcote (1970) also made reference to this unique property of organic manures in maintaining and improving soil fertility. This property is associated with materials which habour ion-exchange sites in their complex structures. Such materials could enable the manure to resist leaching effects. Thus, manures have an advantage over inorganic fertilizers in this regard. The organic and clay fractions of soils are known to have these sites in abundance, but while the nutrient retention/release mechanism of soils has been extensively investigated (Scheidegger and Sparks, 1996; Temminghoff *et al.*, 1994), information on similar studies on manures is lacking. This study was planned to investigate the mechanism and the influence of some factors on the release of potassium from some organic manures in use as alternative sources of plant nutrients.

## MATERIALS AND METHODS

The experimental procedures described under this heading are similar to those reported earlier for soils (Black *et al.*, 1965; Hogg *et al.*, 1993), but which were suitably modified and adapted to the analysis of manure, ensuring that matrix conditions were as close to natural as possible.

The five samples of manures used for this study were those of cattle, duck, local chickens and commercial chickens droppings on bedded and unbedded floors. The bedding material in all cases was essentially wood shavings containing mixtures of sawdust and sand. Three samples each were collected from different farmhouses around the Federal Capital Territory, Abuja, Nigeria. Samples of each manure type were bulked, thoroughly mixed and air-dried at ambient temperature of 38°C (maximum) for 48 hours after the removal of large particles of stones and other foreign materials. The samples were subsequently sieved through a 2mm screen, packed into polythene bags and stored in a refrigerator from where portions were taken for analysis.

*Preliminary determination of pH and native potassium:* The pH of the samples of manure was determined in a 1:4 (m/v) manure-water suspension

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using a pH meter. For the determination of initial water-soluble potassium, about 4g of the manure sample was accurately weighed into a $100cm^3$ polypropylene bottle and about $20cm^3$ of de-ionised distilled water was added. The pH was adjusted to about 7.5±0.2 after which the cap was replaced and the mixture was swirled to allow the manure to disperse. The mixture was shaken on a reciprocating shaker for 2 hours at about 40°C at the end of the period of which it was filtered through a Whatman No. 41 filter paper into a $100cm^3$ volumetric flask. The residue was washed twice with $20cm^3$ of water and the washings were added to the contents in the flask. The volume was then made up to mark and potassium was determined in the solution by flame photometry.

*Cumulative extraction of potassium*: About 1g of each manure was accurately weighed and transferred into five separate $50cm^3$ polypropylene bottles. $20cm^3$ of de-ionised distilled water was added and the bottles were swirled to allow the manure to disperse. The pH was adjusted to 7.5± 0.2 after which the screw caps were replaced and the bottles were clamped on a mechanical shaker with the lower half immersed in water contained in a thermostated bath kept at a temperature of 40°C. The suspensions were then shaken for 2 hours, centrifuged at 2,000 rpm after which they were filtered through a Whatman 41 filter paper into correspondingly labeled $50cm^3$ polypropylene bottles. Two drops of toluene were added to stop further microbial action and kept in a refrigerator, pending the determination of potassium. The residues were transferred back into the appropriate bottles and water was added to bring the total volume of water to approximately $20cm^3$, the pH was adjusted and the suspension was shaken for 2 hours, centrifuged and then filtered as described above. The different filtrates were kept in a refrigerator after the addition of two drops of toluene. The procedure was repeated until eight extractions were completed. Potassium was then determined in the extracts by flame photometry.

*Extraction of added metal ion:*

*Step 1*: $20cm^3$ of an aqueous solution of KCl containing 20mg of the metal ion was added to about 1.0g of manure sample in a $50cm^3$ polypropylene bottle. The suspension was shaken on the mechanical shaker for 2 hours at 40°C, centrifuged and filtered. The residue was retained for the next step.

Step 2: The residue from step 1 was transferred into a $50cm^3$ polypropylene bottle and shaken again on the mechanical shaker for 2 hours after bringing the total volume of water to about $20cm^3$ and adjusting pH. After centrifugation and filtration, two drops of toluene were added to the filtrate and then kept in a refrigerator for the determination of potassium at a later time. The procedure was repeated until the 8th extraction experiment. Potassium was then determined as stated earlier.

*pH-dependent extraction.* The residue obtained from step 1 was treated with $5cm^3$ of de ionised distilled water and the pH of the suspension was then adjusted to 4.0, 6.0, 7.5 or 8.5 with 0.1 mol $dm^{-3}$ NaOH or HCl solution as the case may be. Water was then added to bring the total volume of liquid up to $20cm^3$. The suspension was shaken for 2 hours after which it was centrifuged and filtered. The separate extracts were kept in a refrigerator after addition of two drops of toluene pending the determination of potassium.

*Time-dependent extraction*: De-ionised distilled water was added to the residue obtained from step 1 of the extraction experiment and shaken for 5, 30, 60, or 100 minutes after pH adjustment and the suspension was centrifuged and filtered. The filtrate was treated as described earlier and potassium determined

*Concentration-dependent extraction:* Step 1 of the extraction experiment above was followed, but standard solutions with concentrations of 0.5, 1.0, 2.5,or 5.0 mg $dm^3$ respectively, with respect to potassium were employed in order to test the effect of the metal ion concentration on its extraction. The residues were treated as described in step 2 and potassium was determined in the extract.

## RESULTS AND DISCUSSION

The average values of water- extractable potassium that was initially present in the individual samples of manure ranged from 0.58 (unbedded) to 2.3 g $kg^{-1}$ (bedded). The pH, on the other hand, ranged from 7.6 (unbedded) to 8.1 (bedded). Undoubtedly, organic manures are poor in their nutrient content as reported earlier (Kogbe, 1985; Ofori, 1980; Ifenkwe *et al.*, 1992), but the mineral composition of each manure depends necessarily on its state of decomposition and mineralisation. The weakly basic reaction is also worthy of mention, and is expectedly due to the release of ammonia accompanying microbial degradation reactions.

The curves showing the pattern of the extraction of potassium (figure 1) indicate that there is an increasing reluctance by the manures to release the element after about the 2nd extraction period. Although a plateau was not apparent within the eight extraction numbers investigated, its occurrence at later periods was not unexpected in view of the obvious possibility of the available nutrient reserve becoming exhausted.

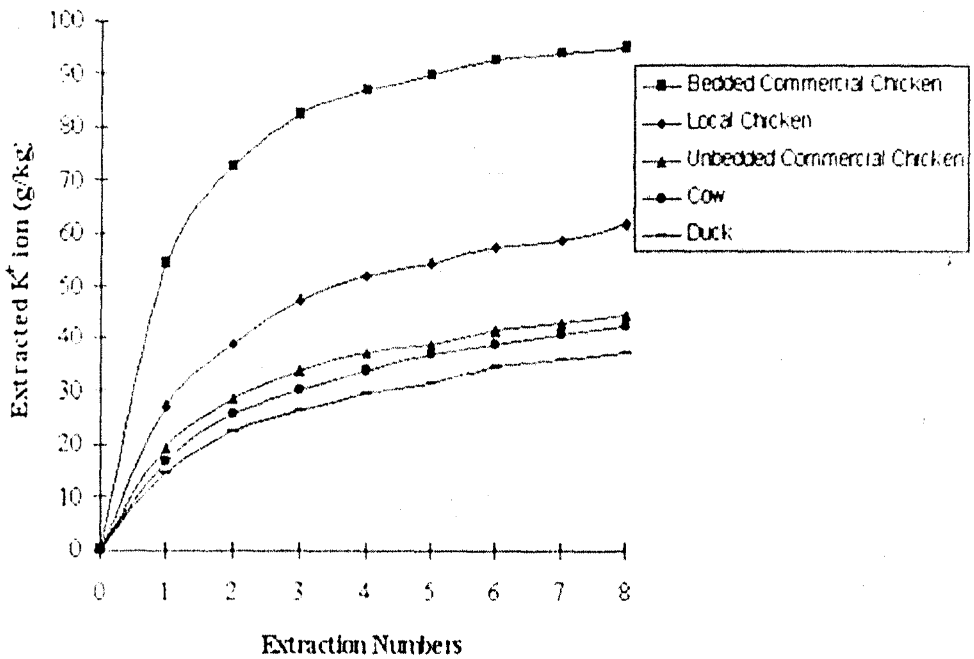


**Fig. 1: Cumulative Extraction of Native $K^+$ from Manure Samples**

The usually high solubility and mobility of potassium in aqueous solution is a useful property in its release phenomenon with respect to fertilizer application in crop production, but which could also be a disadvantage since its effect may be short-lived. However, it is obvious from this study that with manures, the entire available nutrient may not be released to the soil solution in a single process. The amount released in successive processes could be relatively small, but may be sufficient to produce and sustain the desired effect on crops.

In spite of the above allusion to the possibility of exhaustion of the nutrient reserve, the picture presented by figure 2 does not seem to support this view. Certainly, it is unlikely that the concentration of potassium or any nutrient present in the manure would reach a value of zero within a short interval of time. Under natural conditions of the soil environment, decomposition and mineralisation processes would ensure continued release of potassium until all the organic matter have been acted upon. Attention is drawn once more to figures 1 and 2, where initially the rate of release of potassium was fast up to about the 2nd and 4th extraction numbers, respectively. The fast rate is immediately followed by a somewhat exponential portion, after which lower rates became consistent. This is a clear indication that concentration may be a factor in the release of the ion by manures. It was also observed that in both of the extraction experiments, higher rates were recorded with the bedded manures.

*Effect of factors*: The release of potassium from organic manures as affected by the pH of the medium is shown in figure 3. The rise in the amount of the element released with increasing pH value was very much unexpected, since the alkaline metal should show less solubility in alkaline medium. Besides, there is a greater possibility of sparingly soluble compounds precipitating from solution, the more basic the medium. Some of these precipitates are very likely to occlude potassium, thereby rendering it unavailable for determination. Nevertheless, the presence of sodium ions in the medium could lead to the displacement of potassium ions from the manure into solution, and the higher the pH the more the number of sodium ions available to displace potassium. Therefore, the observed effect of pH on the release of potassium from the material is, to a large extent, justified. In addition, it is pertinent to mention that in rationalising the pH factor in the extraction of potassium from organic manures, due cognisance need to be given to the fact of their alkaline reaction, as shown earlier in this report. Moreover, Olsen *et al.*, (1970) observed that the release of nutrients from manures is facilitated by microbial activities, which, according to the authors, are better encouraged in an alkaline environment.

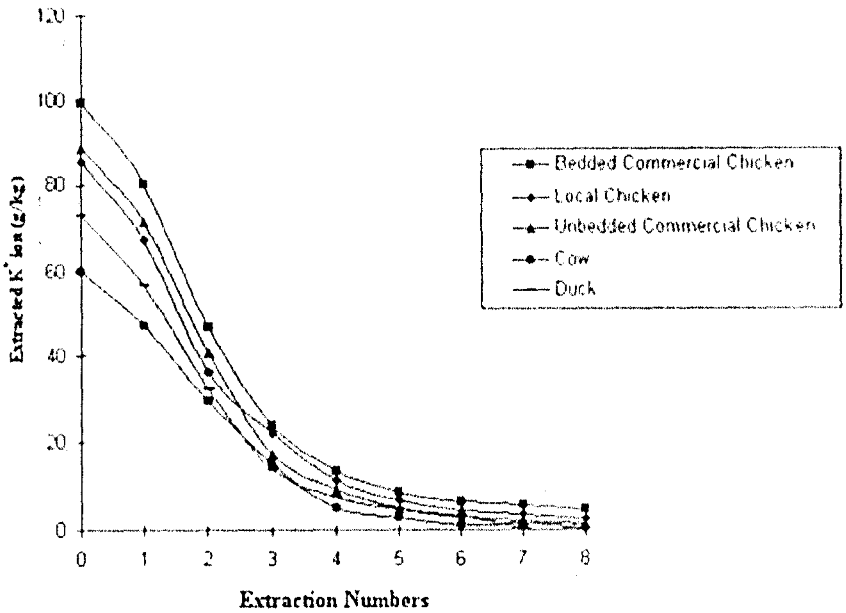


**Fig. 2: Extraction of Added K+ ion from Manure Samples**

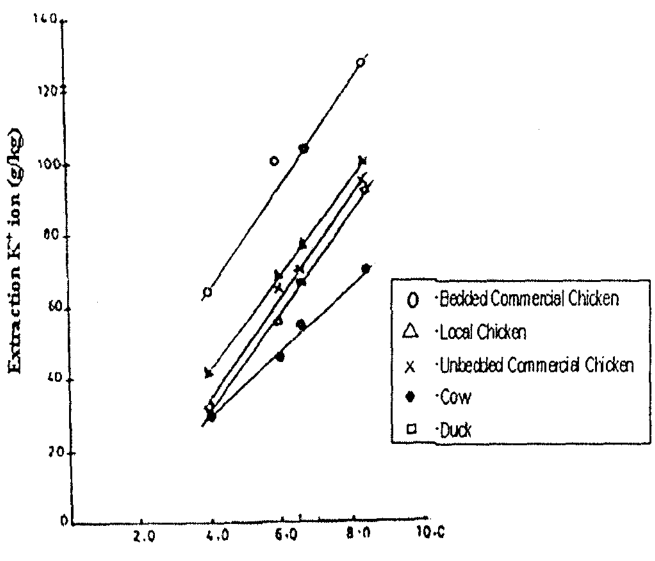


**Fig. 3: pH Dependent Extraction of K+ ion from Manure Samples**

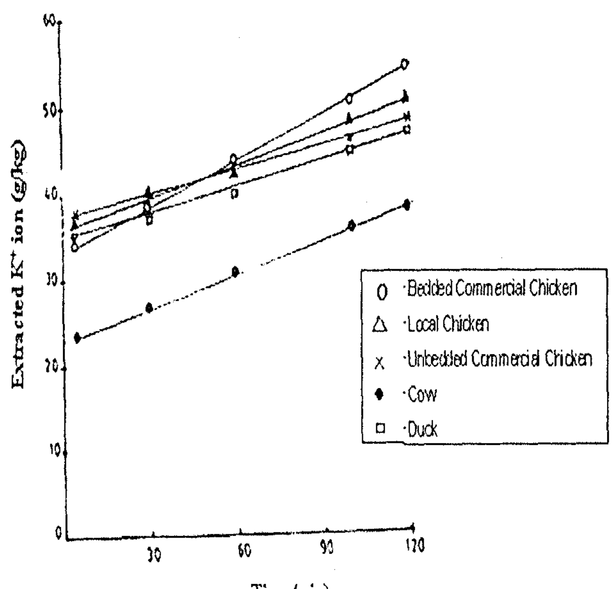


**Fig. 4: Time Dependent Extraction of K+ ion from Manure Samples**

Figure 4 presents a picture that tends to strengthen earlier explanations proposed for the observed behaviour of potassium on extraction from manures (figure 1). Most of the element is released at the very early stages of the extraction process. The amount released continues to increase with time, not necessarily due to the possibility of continuous decomposition of the manures, but perhaps that increase in shaking time permits the forces binding the ions to be sufficiently weakened and subsequently broken. It is also an indication that the difference in equilibration time produced significant decomposition reactions. Although the curves resulting from the extraction of potassium show that the amount extracted increased with increase in the amount of the element in the manure (figure 5), a very striking feature seems to have emerged from this study. It appears that the addition of the element induced the release of more of the native form from the material. The reason for this, though not known, Titiloye *et al.*, (1986), reported results, which showed better yield of crops on application of organic manures combined with chemical fertilizers, than when each of them was applied alone.

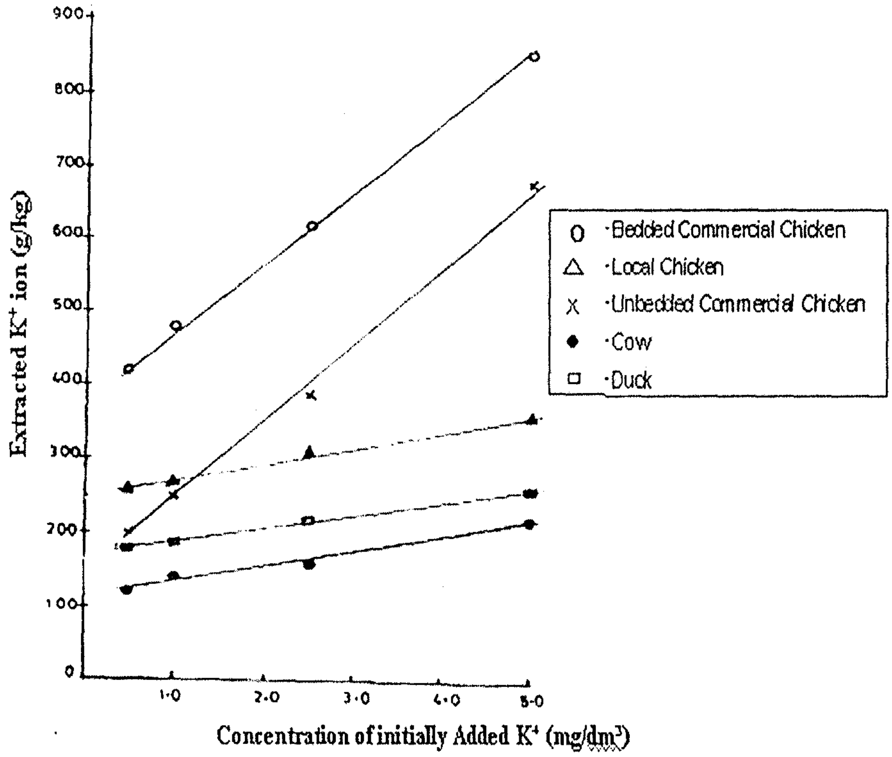


**Fig. 5: Concentration -Dependent extraction of K from Manure Samples**

It is pertinent at this point to comment on the response of the individual manures to the extraction process. In all cases, the bedded floor types showed greater response to the release of potassium. To explain the observation it is perhaps reasonable to have recourse to the surface area of the materials. Without doubt, the bedding material that was applied in order to dilute the poultry droppings may have acted in a way to reduce the particle size and consequently exposed a larger surface for the reaction. A resultant effect of this will be the relatively higher rate of loss of moisture from the manure, thereby concentrating the latter with respect to the nutrient. Moreover, the solubility and mobility of the nutrient will be better enhanced, the smaller the particle size. The validity of these suggestions may not be very obvious, but the differences between the slopes of the curves corresponding to the individual manures offer some support. Besides, it is understandable that the bedding material contributed its own potassium to the nutrient resource of the manures during decomposition. Thus, the higher rate of release of the nutrient observed in the bedded floor manure is attributable to a combination of these two convergent factors. Lower rates of release of potassium were recorded from cow dung and duck droppings. These manures are therefore more likely to produce longer lasting effect on crops, although initial response may be lower than may be obtained with the others.

*Conclusion:* Potassium in organic manure is very soluble and is readily released in aqueous medium. The ease of its release is, however, influenced by pH, equilibration time and concentration of the element in the manure. Organic manures also exhibit their individual characters with respect to the nutrient-release phenomenon, and additives such as bedding materials are important in this respect, probably due to their effect on the surface area of the manure. This assertion is supported by the relatively higher amounts of potassium extracted in the different experiments from the bedded floor manures in this study. Manure from duck droppings and cow dung were, in general, more reluctant to release potassium.

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