Chemistry and Materials Research
ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)
Vol.15 No.1, 2023

Determination of Essential Minerals in Manures of Selected Domestic Animals in Karatina and Their Effects on Soil and Plants

Benson Njau ,Dr. Ann Ngari,Titus Gikuni
Department of Physical and Biological Sciences, School of Pure and Applied Sciences,
Karatina University, Karatina, Kenya
Kimani.njau@s.karu.ac.ke, angari@karu.ac.ke ,kabui.gikuni@s.karu.ac.ke

Corresponding author:Titus Gikuni Kabui
Email address: kabui.gikuni@s.karu.ac.ke

Abstract
Calcium and Magnesium are part of the macro-nutrients required by plants from the soil for growth and development, they are also necessary for soil health to keep crops healthy. Calcium is needed in plants for the formation of new cells, roots, stems, and leaves. For the soil, calcium plays an important role in ensuring the Pretention capacity of water and nutrients. Magnesium is an important component of photosynthesis in plants and is found in chlorophyll which,the green pigment. The study investigated and compared the presence of calcium and magnesium levels in manures of several animals from different households around the Kagochi area. The samples collected were dried, blended and acid digested. AAS, A-A-700,0 (Atomic Absorption Spectroscopy) was used to analyze the manure samples. The data provided was presented in tables and graphs comparing the manures from both households. The mean levels of calcium and magnesium for both households one and two were found to be Ca 27.99 mg/L and Mg 6.23mg/L for household 1 and Ca 27.26 mg/L and Mg 6.32 mg/L for household 2. A strong correlation was found between manures in household one and those of household two in their calcium and magnesium concentrations. The manures were found to contribute a significant rise in soil pH. The information from the study will form a basis for manure's importance and application for small-scale and large-scale crop growers and bring more value to manures as a source of plant and soil nutrients.
Keywords: Manure, Calcium, Magnesium, Nutrients, PH, Fertilizer.
DOI: 10.7176/CMR/15-1-03
Publication date: May 31st 2023

1. Introduction

Food security is one of the biggest issues we face around the world due to the population increase. Due to the need for food security all over the globe great concern is taken to soil on how soil fertility can be improved to increase productivity (Manolikaki et al., 2016). Chemical fertilizers and manures are widely used to promote and enhance soil nutrients needed by plants for growth. Ca and Mg are important nutrients required by plants, Plants absorb mineral elements in their ionic form from the soil or some other medium. That is Ca and Mg and other minerals required for plant nutrition. These elemental nutrients are available to the soil through manure addition and fertilizers (Ruan J et al., 2012).

Manure is organic matter used as organic fertilizer in agriculture. Most manures consist of urine, animal dung, and compost to form animal manure. Animal fertilizers consist of plant materials used as animal bedding that absorb feces and urine. Traditionally and in today's society, almost every household have domesticated animals such as cow, sheep, chicken, pig, and rabbits (Dias et al., 2016). Manure from different animals has different quality and nutrient contents. In the report on environment protection oversaw animal manures are a rich source of macronutrients and micronutrients for crops by providing nutrients to the soil and adding organic matter to improve the physical and chemical properties of soil (Maghanga et al., 2012). Animal manures have a major impact on the microbial community structure of the soil than chemical fertilizers. Fertilizers can directly or indirectly change the chemical, physical, and other soil properties by altering the soil fertility (AI et al., 2012). Animals Manure waste plays an important role in soil improvement through a continuous supply of organic matter and nutrients. Animal slurries are cost inexpensive and cheap, not bulky, environment friendly, and readily available. They provide the soil with the necessary minerals and nutrients needed for plant growth (Mafra et al., 2015).

2. Problem statement

The over-reliance of the soil on chemical fertilizers is a major concern for soil health and plant productivity. The soil is exposed to pollution, leaching of nutrients, soil degradation, and other effects of these fertilizers if excessively used. They lead to deficiency in phosphorous, Potassium, and Magnesium. Groundwater needs protection from phosphorous and nitrogen leaching from chemical fertilizers (Xiong et al, 2017).

Inorganic fertilizers are of high cost in rural areas where some people who live below the poverty level cannot afford to purchase these fertilizers. There is limited information on animal manures domesticated in the households both locally and nationwide which leads the local community to continue using chemical fertilizers despite the availability of cheap manures.

3. Related works

Except for carbon (C), oxygen (O), and hydrogen which plants obtain from air and water plants derive the other four elements from the soil through manure and fertilization (Holzel et al, 2010). For sound soil, it must have all the fundamental minerals components in the right proportion such as Nitrogen (N), Phosphorous (P), potassium (K), Magnesium (Mg), Calcium (Ca), and others. (FAO 2015). The average content of N.P.K on composed cattle manure applied on saffron soil was found to be around 1.1%, 0.6%, and 1.2% dry weight (Maghaddan et al., 2015). Different animal manures were found to have different NPK concentrations, chicken manure was found to have the N.P.K rating 1:1.5:0.5, the cow's 0.8:0.5:0.5, the pig's 0.6:0.4:0.3 and that of the sheep's 0.6:0.4:0.3 (Macdonald et al 2021).

Application of swine (pig) manures and cattle manures together with N.P.K increased the total organic carbon by 78.3% and 54.7%respectively (Liet et al., 2017). Kenyan soils suffer from macronutrients and micronutrients such as N, P, K, Ca, Mg, and S (Kibunja et al, 2017). Farmyard manure contains all required nutrients and can supply them to the soil that is (N, K, P, Ca, Mg, S) necessary for plant growth (Khan et al 2010). (M. Desene et al., 2012) farm yard manures can improve soil water holding capacity, soil structure, and nutrients exchange and maintain soil health.

Calcium increases in soil help in increasing the soil PH by reducing soil acidity and nutrient leaching (Omolla et al., 2016). In western Kenya, farmland soils are widespread with Ca, Mg, N, and P deficiencies and have soil PH of 4.5 to 5, due to excessive leaching of Ca, Mg, and K. NPK blended fertilizers popularly used in combination with manure application on maize led to increased uptake of plants nutrients such as Mg, Ca and N.P.K (Bernard et al., 2015). Manures from swine brought about a significant increase in N, P, Ca, and Mg levels in de camp ben plants. (Silva et al., 2015). The use of swine /pig waste as a nutrition source for crops gradually increased due to the ability to improve soil chemical properties. (Mead et al 2011) (Oliveira et al., 2014). Animal manure of goat and sheep have a large concentration of nitrogen (N), calcium (Ca), and manganese (Mn). Sheep manures were found to contain phosphorous (p) and potassium (K) in higher concentrations than cattle manure (Hejcman et al., 2013). Naturally, pig manure applications are found to allow more complete nutrient fertilization not only limited to N, K, and P but with a high concentration of macro and micronutrients such as Ca, Mg, Zn, and Mn (Comin et al., 2016 and Siva et al., 2020). Pig manures are used as fertilizers.

Maintaining soil quality is of great importance for crop productivity. Livestock manures return essential macronutrients including nitrogen, K, P, Mg, Ca and others to soil maintaining its fertility (Wang et al., 2019). Calcium uptake by the plant is related to root carbon exchange capacity. The soil has the capacity of exchanging Ca with plant roots. The Significant increase in exchangeable Ca levels and enhanced Ca uptake affect the addition of cow manures (Uzoma et al., 2011). An increase in K availability in soil is attributed to enhanced soil PH by cow manure (Manolikaki and Diamodopoulus 2016, Sminder and Sings 2014). Fertilization with composed swine manure exports values for N, P, K, Ca, Mg and S or higher than those obtained with mineral fertilization (NPK) indicating that compost swine manure can be efficient as a mineral fertilizer in the supply and export of nutrients in the prose millet crop (Alves et al., 2017).

4. Material and Testing Methods

4.1 *Study Area*

The study aimed to analyze potassium (K), calcium (Ca), and magnesium (Mg) concentrations in cattle, pigs, sheep, and a mixture of the manures that were collected from an area in the Mathira constituency, Magutu, and Kagochi sub-location in Nyeri County. Kagochi area is located at 1761m above sea level, latitude (0◦ 23' 24.7''S) and longitude (37◦ 8' 37.1'' E). The area is situated within Mathira constituency, Magutu ward, Nyeri County, Kenya. The main crops grown in the area are crops like Tea, maize, vegetables, and coffee. Animals reared in the area include dairy cattle, sheep, goats, rabbits, pigs, and poultry.

4.2 *Sample Collection*

A sampling of manure was carried out in March and April 2022. Manure samples were collected systematically from two households in each household only samples of pig manure, cattle manure, and sheep manures were collected. The samples (n=6) from the households (A1, A2,), (B1, B2, B3) were collected at an interval of 10 blocks apart and a mixture sample (D1, D2) was prepared.

The soil samples were collected, and sample numbers were (n=8) all from within Karatina university garden and were labeled (A, B, C, D, E, F, G, H & I). The manure samples were collected 300 g each for all the animal manures which were under the study.

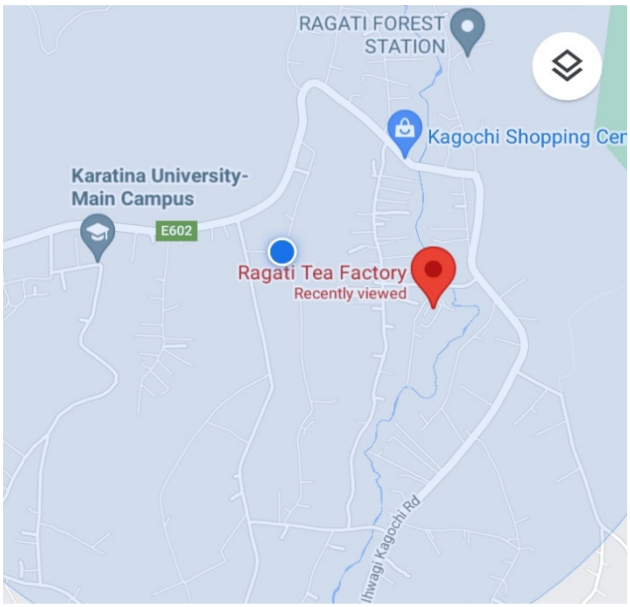

Fig. 1 GPS location of Kagochi area.

The samples were sieved to remove leaves and then placed in 500g plastic containers. The household where the manures were collected were marked by red ribbons at the gate their GPS locations were also noted. The soil samples were collected 15 cm deep using a soil auger where a panga was used to dig, and the soil was placed in a 5000 ml plastic container. The soil was collected 4 times at a distance of 15 m apart and later mixed to have a uniform representative sample which also was subdivided to cater for all the samples that were needed. All the samples were later taken to Karatina university laboratories where sample analysis was done

4.3 *Sample Preparation*

The manure samples collected were air dried and later dried. The dried manure samples were ground using a blender to get homogeneous finely ground samples and were stored in plastic bags as they waited for laboratory analysis and acid digestion.

4.4 *Sample Digestion*

Manure sample digestion was done where 2 g of each sample were weighed using an analytical electronic weighing balance, the samples will be placed in a test. 10 ml of nitric acid, sulfuric acid and per chloric acids were added in the ratio of 6:3:1 into each sample and were thoroughly shaken. The samples were allowed to stand and later were heated to 100 °C for an hour and after one hour the temperature was raised to 350 °C for three hours, later the samples were allowed to cool to room temperature.

The digested samples were left to cool; distilled water was added to each sample. The samples were filtered between filter paper after all the samples were dissolved. The filtrates were placed in a 50 ml flask and were made up to the mark using distilled water and stored for analysis. Analysis of the samples was done under atomic absorption spectroscopy (AAS) whose number will be provided.

4.5 *Preparation of Standard Solution*

100 ppm of Calcium was prepared from a 1000ppm commercial standards of calcium in a conical flask and was made to the mark, standards of 2ppm, 4ppm, 6ppm, 8ppm and 10 ppm standard solutions were prepared from dilutions of 2ml, 4ml, 6ml, 8ml and 10ml in a 100ml volumetric flask and made to the mark. 100ppm of magnesium were prepared from 1000ppm of commercial standards in a conical flask and later made to the mark. Standards of 2ppm, 4ppm, 6ppm, 8ppm and 10ppm were prepared from dilution of 2ml, 4ml, 6ml, 8ml and 10ml in a 100ml conical flask and made to the mark.

4.6 *Determination of Soil PH*

Determination of soil pH samples was done using distilled water which was added to 50g of air-dried sample in a 50ml beaker. The mixture was stirred and was left for three days. The soil pH was determined using a pH meter. A mixture of each manure sample, was mixed with a soil sample and distilled water, and they were left for three days, later the pH of the mixtures was determined using a pH meter.

4.7 *Chemical Reagents and Apparatus*
The chemical reagents and apparatus that were used include:

Table 1 Chemical Reagents and Apparatus

APPARATUS	REAGENTS
3 Conical flasks	Per chloric acid
1 Pipette	Concentrated sulfuric acid
12 Test tubes	Concentrated Nitric acid
5 Beakers	
3 Measuring cylinder;2-250ml and one 10ml cylinders	
1 Blender	
1 sieve	
12 Plastic cointainers	
1 soil scooper	
4 Volumetric flasks	
1 Ph meter	

4.8. *Data Analysis and Data Presentation.*
The data obtained were analyzed using the excel model of data analysis, later the data that were obtained were presented using tables and bar graphs. The concentration of each element of Mg and Ca was presented using bar graphs showing the concentrations of each element in the manures. The soil PH of different animal manures was presented using a table of PH.

5. Results and discussion

Table 2. A table of calcium and magnesium concentrations in manures.

	CALCIUM(concentration in ppm)		MAGNESIUM(concentration in ppm)	
Manure	HH1	HH2	HH1	HH2
COW	45.0297	28.5927	0.0000	0.0000
SHEEP	21.9205	42.3438	8.2721	7.9362
PIG	28.6061	20.0658	8.4641	8.4713
MIXTURE	16.4148	18.0503	8.6085	9.9800

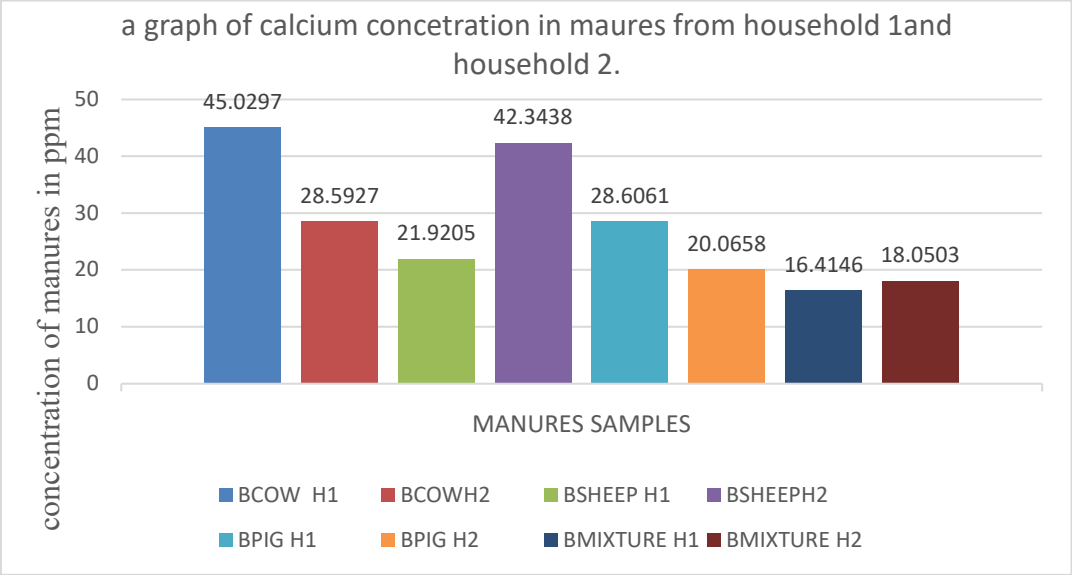

Fig 2 A graph of calcium concentration in manures of household 1 and household 2.

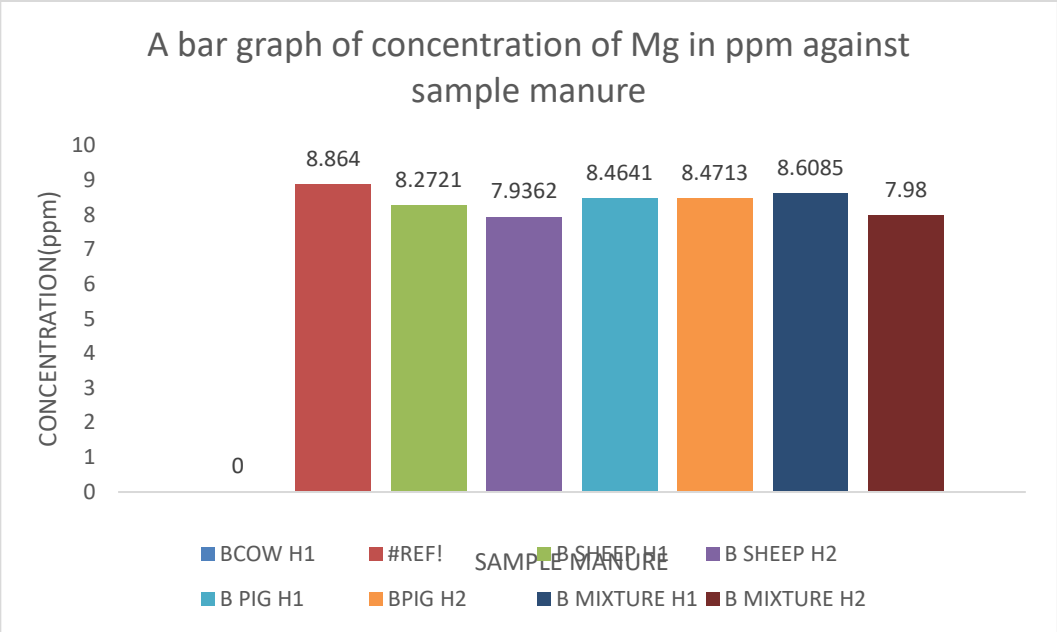

Fig 3 Graph of magnesium concentration in manure concentration of household 1 and household 2.

Cow manures contained the highest levels of calcium for manures in household one but also had the least magnesium content. Sheep manures reported a significant amount of calcium and magnesium levels within the manures. Pig manures registered a higher level of calcium and magnesium which were greater than those of the sheep manures. The mixture was made by mixing 0.667g of each manure from the three animals. The mixture registered the least amount of calcium but had a significant amount of magnesium. All the manure from household number 1 registered significant levels of calcium and magnesium except the cow dung which had the least calcium content. The means of calcium and magnesium were Ca = 27.99 and Mg = 6.32 respectively in household one.

Animals in the household were fed on pastures ad fodders, commercials feed (daily meals, fish meals), salt licks, and water. Also, they were fed vegetables from the farm and dry Napier grass.

Manures from household 2 had calcium and magnesium content of means 27.26 and 8.81 respectively. The sample manures reported higher calcium content than those of magnesium, the sheep manures reported the highest calcium concentration and also higher magnesium concentration as compared to the other manures samples. The cow manure also registered a significant level of calcium and magnesium. The mixture was made by mixing 0.667g of each manure from the three animals. The mixture had relatively lower levels of calcium and magnesium than those from pig manures.

The ratio of calcium to magnesium in household 1 was found to be 4.42mg/L while the ratio of calcium to magnesium from household 2 was 3.28 mg/L.

Animals in household 2 were fed through cut ad carry method the animals were fed with different types of feed, including grass, vegetable wastes, commercial feeds (daily meals and pioneer feeds) animals' licks, and river water.

Table 3 A table for manures pH before adding soil ad after adding soil for household 1 and household 2.

	HH1		HH2	
MANURES	pH before	pH after	pH before	pH after
COW	9.12	9.07	8.78	8.62
SHEEP	8.80	8.76	9.58	9.51
PIG	8.85	8.80	8.50	8.28
MIXTURE	8.75	8.60	8.71	8.70

The pH of the soil was 7.21 before manure samples were added.

In addition to various types of manures after some time, the pH raised to different values as per the manure used. For household 1 cow manures raised the soil pH highest while the other manures had no significant difference in their pH values of the soil-manure mixture.

Sheep manure from household 2 registered the highest levels of pH in the manures. Cow manures also indicated a significant value of pH change in the manure, the mixture raised the pH higher than the pig manures indicating a more basic character than pig manures.

The results in table 2, shows the concentration of calcium and magnesium in animal manures, concentration of calcium and magnesium present in animals manures depends on the animals' intestinal functions and the health

of the animal, the physical, chemical and biological properties of the animals feeds they are fed (Dong et al., 2014, Gong et al., 2012). Animals in household 1 and those in household 2 were fed with close to similar feeds but due to factors of their age, health, and intestinal functions which were different hence differed in the concentration of calcium and magnesium. Manures calcium and magnesium elements are found in a combined form of oxides, carbonates, or metal complexes with organic matters, therefore manures can be used as organic fertilizers with macronutrients of calcium and magnesium which are essential for plants growth (Tsai et al., 2012). Table 2 indicates that (cow, sheep, and pig) manures contain different levels of calcium and magnesium which they incorporate into the soil when used . Manures, therefore, have a direct effect on availing calcium and magnesium in the soil and other physical and chemical properties needed for soil health (Mosa et al., 2014).

The pH of the soil varies depending on the chemical composition of the soil, organic fertilizers increase the soil cation exchange capacity of the soil when applied in the soil attributing to soil organic substances and increase in calcium and magnesium in the soil, this increases the pH of the soil with the application of organic fertilizers in the soil (Goldberg et al 2020). Soil pH increased when various animal manures were added to the soil samples. Household 1 manures increased the soil pH with cow, by 26.12%, sheep, by 21.50%, pig, by 22.05%, and the mixture by 21.36%, and household 2 increased the soil pH with cow by 21.78%, sheep, 31.90%, pig, 17.89%, and the mixture with 20.67%. Manures application in farms increases the soil organic matter and improves the soil pH (Cai et al 2019).

The availability of calcium and magnesium in the animals' manures affects the pH of the effluent as they provide alkalinity in the manures thus providing high pH values. Organic manures increase the pH of the soil when applied in the soil due to the residual effect and alkalinity of the manures which in return increases the pH of the soil due to elemental counterbalance in the soil (Rukshana et al., 2013).

5.1 *Sources of Calcium and Magnesium*

The mode of feeding, type of feed and other factors directly or indirectly related to the animals are great contributors to the calcium and magnesium availability in animal manures. Feeding animals with the vegetative plant is a method used by most farmers to feed their animals on farms where crops and animals are reared (David G et al 2017). The levels of calcium and magnesium varied differently in various animal fertilizers in household 1 and household 2. It has been hypothesized that the concentration of calcium and magnesium in the manures is a result of animal feeding patterns providing the animals with a sufficient amount of calcium and magnesium. Locally in (HH1 and HH2), animals are fed leafy plants, grass, vegetables from local farms, commercial feeds and hay. Additionally, the animals' licks and water are used to feed the animals to stay healthy and provide enough calcium and magnesium in their bodies (Neville et al., 2010). The excess of these minerals is excreted and is found in their dungs. Leaf beddings for the animals may also have contributed a significant amount of calcium and magnesium in the animal manures, as farmers used grass as the animal bedding due to decomposition nutrients cycling between the undigested leaf beddings and the animals' wastes to form manure.

The feeding system of both households used commercial feeds to feed their animals, aim feeds contain the essential elements of calcium and magnesium needed for the animals to grow and in return, they excrete them in their urines and feces and their manures. (Guo et al., 2018). The concentration of calcium and magnesium in the urine, feces, and manures of animals differs from one animal to another due to their different digestion compared to the study where animals had different digestive systems. Table 2 show the different concentration of calcium and magnesium in different animal manures, cow (ruminant), sheep (herbivore), and pig (omnivore) (Simon et al., 2019).

6. Conclusion and Recommendations

The objectives of the study were effectively achieved. The essential minerals in manures of selected animals were determined and compared and the effects of each animal manure on the soil PH were determined. Manures of different animals contain different levels of calcium and magnesium. The presence of different concentrations of calcium and magnesium concentrations is influenced by the; type of feed that the animals are fed with, beddings, and age of the animals (Cai et al., 2018). The high levels of calcium and magnesium found in animals' manures are influenced by their concentrations in animal feeds such as grass, animals' salts, water, the concentration of commercial feeds, and the antibiotics with which animals are injected. Animals' manures cause an increase in soil pH, all the manures from the different animals (cow, sheep, pig, and a mixture of the three manures) in both households had a different percentage increase in soil pH Animal manures increase the soil pH where necessary. Domestic animal manures can be used to support and improve the levels of calcium and magnesium in the soil to meet the levels needed by plants for their absorption.

Manures from domestic animals can be used in agricultural practices at recommended rates as they are environmentally friendly and can be used to reduce agricultural pollution. Contrary to inorganic fertilizers, organic fertilizers reduce exchangeable calcium and magnesium, and animals' fertilizers improve the calcium and magnesium levels in the soil as well as the pH of the soil.

The future works of this study recommended are;

- Establishment of manures as an alternative to be used as fertilizers inputs for crops productions.
- The study suggests that farmers can use animals' manures as an alternative to raise soil pH in acidic soils rather than using calcium oxide as manures add other values to the soil.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to acknowledge Karatina University which partially funded our work,our supervisor Dr.Ann Ngari,and the lab technicians for their guidance and assistance whenever we needed it.

References

1. Manolikaki I. and Diamadopeulos E. 2016. Regress yield and nutrient status after biochar application in two Mediterranean soils archive of agronomy and soil science. Manure h2g2 July 15, 2010 retrieved 23 July 2017.
2. RuanJ Mal, Yana Y. Magnesium nutrition on accumulation and transport of amino acids in tea plant. J sci food Agri 2012:92 (7):1375-83.
3. Dias, V.V., Talamini, E., Revillion, J. P. P., Schuster, M. S. Scale of consumer loyalty for organic food. British Food Journal information 118, 2016, 697-713.
4. Maghanga JK, Kisinyo PO, Kitunyi JL, Ngetich WK. 2013. Impact of Nitrogenous fertilizers application on surface water nitrate levels within Kenya tea plantation chem (9):196516.
5. AI C, Liang GQ, Sun JW, Wang XB, Zhou W. Responses of extracellular enzyme activities and microbial community in both the rhizospHere and bulk soil to long-term fertilization practices in a fluvo-aquic soil. *Geoderma*. 2012;173: 330–338.
6. Mafra, M.S.H., Cassol, P.C., Albuquerque, J.A., Grohskopf, M.A., Andrade, A.P., Rauber, L.P., Friederichs, A (2015). Organic carbon contents and stocks in particle size fractions of a Typic Hapludox fertilized with pig slurry and soluble fertilizer. Revista Brasileira de Ciência 1161-1171
7. Xiong W, Jousset A, Guo S, Karlson I, Zhao Q, Wutt Kowalchute GA Shen Q, Li R Geisen S(2017). Soil Protist communities form a dynamic hub in the soil microbiome ISNEJ.:12(2):1-5.
8. Hölzel C.S., Schwaiger K., Harms K., Küchenhoff H., Kunz A., Meyer K., Müller C., Bauer J (2010). Sewage sludge and liquid pig manure as possible sources of antibiotic resistant bacteria. Environ. Res; 110:318–326.
9. Adekiya, A. O 2018. Legume mulch materials and poultry manure affect soil properties, and growth and fruit yield of tomato. Agric. Conspect. Sci. 83(2), 161–167
10. Alves, C. de F., Cassol, P. C., Sacomori, W., Gatiboni, L. C., Ernani, P. R., Aita, C., Panisson, J., & Ferreira, A. K. T. (2017). Influence of fertilization with swine manure and mineral fertilizer added by nitrification inhibitor on corn yield and nutrition. *Revista de Ciências Agroveterinárias*, *16*(1), 2–10.
11. Hejcman, M., Berková, M., & Kunzová, E. (2013). Effect of long-term fertilizer application on yield and concentrations of elements (N, P, K, Ca, Mg, As, Cd, Cu, Cr, Fe, Mn, Ni, Pb, Zn) in grain of spring barley. *Plant, Soil and Environment*, *59*(7), 329–334
12. Bak, J. L., Jensen, J., & Larsen, M. M. (2015). Belysning afkobber- og zinkindholdet i jord. Aarhus: DCE – Nationalt Center for Miljø og Energi, Aarhus Universitet, Institute for Bioscience.
13. Benedet, L., Comin, J. J., Pescador, R., de Oliveira, P. A. V., Belli Filho, P., De Conti, L., and Brunetto, G. 2016. Physiological changes in maize grown in soil with copper and zinc accumulation resulting from the addition of pig slurry and deep litter over 10 years. Water Air Soil Pollute. 227, 401.
14. Chagundo, M.G.G., Mwangwela, A., Mumba, C., Dos Anjos, F., Kawonga, B.S., Hopkins, R.2016. Assessing and managing intensification in smallholder dairy systems for food and 705 nutrition security in Sub-Saharan Africa. Reg. Environ. Change 16, 2257–2267. 706 https://doi.org/10.1007/s10113-015-0829-7
15. Dong, W.Y., Zhang, X.Y., Dai, X.Q., Fu, X.L., Yang, F.T., Liu, X.Y., Sun, X.M., Wen, X.F.,Schaeffer, S., 2014. Changes in soil microbial community composition in response to fertilization of paddy soils in subtropical China. Appl. Soil Ecol. 84, 140–147.
16. Edwards, J. E. H., Masters, D. G., Winslow, E., Hancock, S., Thompson, A. N., Refshauge, G.. & Friend, M. A. (2018). Calcium and magnesium status of pregnant ewes grazing southern Australian pastures. Animal Production Science, 58(8), 1515-1521.
17. FAO 2015. Healthy soil is basis for healthy food production. Https://www.Fao.org /s/ a- 14405e pdf.
18. Goldberg, N.; Nachshon,U.;Argaman, E.; Ben-Hur,M 2020. Short term effects of livestock manures on soil structure stability,runoff and soil erosion in semi-arid soils under simulated rainfall.Geoscience.10, 213.
19. Gong, W., Liu, X., He, H., Wang, L., Dai, G., 2012. Quantitatively modeling soil–water distribution coefficients of three antibiotics using soil physicochemical properties.Chemosphere 89, 825–831.

20. Guo T, Lou C, Zhai W, Tang X, Hashmi MZ, Murtaza R, Li Y, Liu X, X J (2018) Increased occurrence of heavy metals, antibiotics and resistance genes in surface soil after long-term application of manure.Sci Total Environ 635:995–1003. https://doi.org/10.1016/j.scitotenv.2018.04.194
21. Li F, Chen L, Zhang J, Yin J and Huang S (2017) Bacterial Community Structure after Long-term Organic and Inorganic Fertilization Reveals Important Associations between Soil Nutrients and Specific Taxa Involved in Nutrient Transformations. Front. Microbiol. 8:187. doi: 10.3389/fmicb.2017.00187
22. M. Desene and M. Lemlen integrated agronomic crop management to improve the productivity under terminal drought in 1 Md M Rahman and H Husegawa eds water stress in Tec open science 2012 pg. 255-254
23. Mosa WFAE-G, Paszt LS, Abd EL-Megeed NA 2014. The role of bio-fertilization in improving fruits productivity—A review. Adv Microbiol.;4(15):1057.
24. Neville, F. Suttle, 2010. Honorary Research Fellow Moredun Foundation Pentland Science Park Bush Loan Penicuik Midlothian EH26 0PZ UK: Mineral Nutrition of Livestock, 4th Edition..
25. N.I Khan A.U Malik F Umer and MI Bodla. Effects of tillage and farm yard manure on physical properties of soil, international research journal of plants scions vol 1 No.4 2010 pp 75-85.
26. Omollo JO, Semu E, Msaky J, Owuor P. Effects of cropping system and agricultural lime on soil properties and nutrient content of sugar cane on acidified soils of Kisumu County, Kenya. American journal of Agriculture forum 2016 44:97-111.
27. Rukshana F, Butterly CR, Xu J-M, Baldock JA, Tang C (2013) Organic anion-to-acid ratio influences pH change of soils differing in initial pH. J Soils Sediments 14:407–444. https://doi.org/10.1007/s11368-013-0682-6.
28. Rayment GE and Lyons D.J (2011). Soil chemical methods: Australia CSIRO publishing.
29. Silva AA Lana AMQ, Lana RMQ, Costa AM (2015) fertilization with swine manure influence on bromatological characteristics of branchiria de campben and charges in soil journal of Brazil Agriculture Olivera Da de, Pinheiro A, Veiga M da (2014). Effects of pig slowly application on soil physical and chemical properties and glyphosate mobility Rev Bras Cienc solo 38(5):1421-1431.
30. Simon Svane & Henrik Karring | (2019) A comparison of the transitionmetal concentrations in the faeces, urine, and manure slurry from different livestock animals related to environmentally relevant microbial processes, Cogent Chemistry, 5:1,1644702, DOI:10.1080/23312009.2019.1644702
31. Sheid DL, Silva RF, Silva VR, Ros CO, Pinto MA, Gabriel M, Cherubin MR. Changes in soil chemical and physical properties in pasture fertilized with liquid swine manures, Scientia Agricola 2020;77(5).
32. Sminder and Singh B 2014. Agronomic performance of high ash biochar in two contrasting soil agriculture ecosystem and environment 191:99-107.
33. Tsai, W., Liu, S., Chen, H., Chang, Y., Tsai, Y., 2012. Textural and chemical properties of swine-manure-derived biochar pertinent to its potential use as a soil amendment. Chemosphere 89, 198–203.
34. Uzoma K et al 2011. Effects of cow manure biochar on maize productivity under sandy soil condition soil use and management 27(2): 205-212.
35. Van Zwieten, L., Kimber, S., Morris, S., Chan, K.Y., Downie, A.,Rust, J., Joseph, S. & Cowie, A. 2010. Effect of biochar from slow pyrolysis of papermill waste on agronomic performance and soil fertility. Plant and Soil, 327, 235–246
36. Wang W.J., Zhu Dan Y, Wang HS.2010. Effects of different amount of organic fertilizer in the yield of organic vegetables north Hortic17:29-30.
37. Cai, M. Xu, B. Wang, L. Zhang, S. Wen, S. Gao 2018.Effectiveness of crop straws, and swine manure in ameliorating acidic red soils: a laboratory study J. Soils Sediments, pp. 2893-2903, 10.1007/s11368-018-1974-7