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Comparative Study of the Chemical Contents in locally used Organic and Inorganic Fertilizers

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ABSTRACT

This study aimed to compare the chemical content of organic and locally used inorganic fertilizers. Three types of organic fertilizers (sheep, chicken, and pigeon manure) and three inorganic fertilizers (Sulostate, Compound, and Monoammonium phosphate) were selected for analysis. The laboratory analysis revealed that the moisture percentage in sheep manure (sample A) was 20%, similar to that of commercial fertilizers. On the other hand, both chicken and pigeon manure had a moisture percentage of only 4%. The ash percentage was highest in sample F at 92%, and lowest in sample E at 10%, while the values were similar in the organic fertilizers. In terms of protein content, the range in organic fertilizers was between 12.75% and 15.98%, while in commercial fertilizers, the highest protein content was found in the compound fertilizer (sample E) at 31.14%. The chemical content analysis was performed using XRF. However, highest percentage of phosphate was found in sample F at 65.2%, and the lowest in sample A at 2.89%. As for potassium, the highest percentage was 60.7% in sample E, and the lowest was 1.54% in sample F. The organic fertilizers contained higher percentages of calcium (34.1%), with the highest percentage found in sheep manure (sample A). They also contained silicon, aluminum, iron, and other elements such as iodine, titanium, and trillium. Additionally, they contained substantial amounts of sulfur and copper, making them a suitable alternative for plant nutrition and soil improvement.

دراسة مقارنة المحتوى الكيميائى لبعض الاسمدة العضوية والصناعية المستخدمة محلياً

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وتهدف هذه الدراسة إلى مقارنة المحتوى الكيميائي للأسمدة العضوية والأسمدة الصناعية المستخدمة محلياً. واختيرت ثلاثة أنواع من الأسمدة العضوية (الخشب، والدجاج، وسماد الحمام) وثلاثة أسمدة غير عضوية (المركب، والكمبوس، وفوسفات مونامونيوم) لتحليلها. وكشف التحليل المختبري أن نسبة الرطوبة في سماد الأغنام و الأسمدة التجارية 20 %، ومن ناحية أخرى، كان لكل من الدواجن والسماد الحمامي نسبة رطوبة قدرها 4 في المائة فقط. وكانت نسبة الرماد الأعلى في العينة F عند 92 %، والأدنى في العينة E عند 10 %، في حين كانت القيم متشابهة في الأسمدة العضوية. وفيما يتعلق بالمحتوى البروتيني، كان نطاق الأسمدة العضوية يتراوح بين 12.75 % و15.98 % المائة، بينما في الأسمدة التجارية، و أعلى محتوى بروتيني في الأسمدة المركبة عند 31.14 %. وقد أُجري تحليل المحتوى الكيميائي و XRF كما وجدت أعلى نسبة مئوية من الفوسفات في العينة F عند 65.2٪، والأدنى في العينة ألف عند 2.89٪. وفيما يتعلق بالبوتاسيوم، كانت أعلى نسبة مئوية هي 7.60 في المائة في العينة E، وتتضمن الأسمدة العضوية نسباً مئوية أعلى من الكالسيوم (34.1 %)، وتوجد أعلى نسبة مئوية في سماد خراف .(sample A) كما تحتوي على السيليكون ، الألومنيوم ، الحديد ، وغيرها من العناصر مثل اليود ، التيتانيوم ، والتريليوم . وبالإضافة إلى ذلك، تحتوي على كميات كبيرة من الكبريت والنحاس، مما يجعلها بديلا مناسبا لتغذية النباتات وتحسين التربة

INTRODUCTION

The negative consequences on the environment and human health are a major worries with the rising use of chemical fertilizers. There are two types of fertilizers: inorganic (chemical/mineral) and organic.

Chemical fertilizers have been overused globally due to their long-standing reputation as the most direct and efficient means of boosting production. They are widely employed to improve agricultural yield (Zhang, et al., 2014). Chemical fertilizers, which mostly consist of nitrogen, phosphate, and potash (Morari, et al., 2011), have significantly supported the world's rising population (Sarwar, et al., 2021). However, the cost of manufacture (raw material and capital costs) is what makes these fertilizers so expensive (World Bank, 2006). However, using chemical fertilizers excessively damages the soil, water, atmosphere, etc., aggravating environmental degradation(Qin, et al., 2020, Iqbal, et al., 2020). Acidification and compaction of the soil, a decrease in the amount of organic matter, and heavy metal pollution are signs of soil deterioration (Liu, et al., 2020, Zou, et al., 2020, Naila, et al., 2019). Additionally, the overuse of chemical fertilizers pollutes the soil, which has an impact on human health along the food chain (Corguinha, et al., 2015).

A fallow rotation system, soil testing, formula fertilization, and substituting chemical fertilizer with organic fertilizer are some methods to reduce the use of chemical fertilizers (He, et al., 2020). Thus, there is a need for an efficient method for creating organic fertilizer that is proficient, inexpensive, and environmentally friendly (Majee, et al., 2021).

Applying organic fertilizer is a crucial step toward raising the caliber of agricultural output and achieving agriculture's sustainable growth.

Natural sources that are recycled plant or animal-derived debris and provide a sufficient amount of plant nutrients are known as organic fertilizers (Shahena, et al., 2021, Epule, et al., 2015, Shaji, et al., 2021). Organic fertilizers can boost soil fertility, raise nitrogen consumption efficiency, and enhance soil preservation capabilities, all of which can ultimately improve the quality of agricultural output (Hafez, et al., 2021).

The creation of eco-friendly compost using solid organic manure may be a successful alternative to increasing soil fertility (Majee, et al., 2021, Liu, et al., 2011).

Some advantages of using organic fertilizers include enhancing crop production and quality, preserving soil fertility, reducing water pollution in rivers, lakes, and groundwater, and using fewer nonrenewable external inputs (Shaji, et al., 2021). Composting, mulching, green manuring, and crop rotation all help to end nutrient cycles (Kanda, et al., 2015).

Organic manures do contain some plant nutrients, but not as much as inorganic fertilizers. It has been discovered that using inorganic fertilizer to boost output is efficient in the near term but necessitates regular application over time.

Investigating the utilization of inexpensive, environmentally friendly, locally obtained organic materials as a means of enhancing and maintaining crop and soil production is so crucial.

The chemical content of chicken, pigeon, and sheep manure plays a crucial role in determining their nutrient value and potential environmental hazards (Moreno-Caselles et al., 2002). Studies have shown that the chemical composition of organic fertilizers, such as chicken and sheep manure, can significantly impact the productivity and essential oil content of plants like dill (Khalid & Shafei., 2005). Additionally, the effects of chemical and organic fertilizers on saffron flowering have been investigated, highlighting the importance of understanding the nutrient content of different manures (Jahan., 2006). Nitrogen mineralization from various manures, including chicken and sheep manure, is influenced by their chemical composition and soil type, emphasizing the need to consider the nutrient richness of these organic materials (Mubarak et al., 2010). Furthermore, bio-char derived from high-nutrient biomasses like chicken manure has been identified as a potential liming agent for acidic soils, with its agronomic value being regulated by the nutrient content of the biomass (Domingues et al., 2017). Research has also explored the impact of different organic nutrients, including sheep and pigeon manure, on the quality properties of crops like popcorn, demonstrating variations in cob ratio, kernel weight, test weight, and popping volume based on the type of manure used (Cihangir & Oktem., 2019). Moreover, the effects of organic wastes, such as chicken and sheep manure, on the structural characterizations of fulvic acid in semiarid soil have been studied, highlighting the importance of understanding the chemical properties of organic fertilizers (Wu et al., 2019). Animal solid waste, including chicken and sheep manure, has been identified as a potential renewable biomass energy source, with variations in volatile matter and ash content observed among different types of manures (Alnhoud et al., 2021). Additionally, the effects of different organic manures, including sheep manure, on the yield and yield components of olive trees have been investigated, underscoring the importance of considering the chemical composition of organic fertilizers in agricultural practices (Isa et al., 2021).

The use of organic fertilizers has been shown to have a positive impact on soil fertility and nutrient content. Shi et al. (2019) found that the application of fungal residue and chemical fertilizers in paddy fields increased nutrient content and soil organic carbon turnover rates. Similarly, Singh et al. (2020) emphasized the role of organic fertilizers in improving soil fertility. Teliban et al. (2020) observed that chemical fertilization resulted in higher leaf dry matter and nitrate content compared to unfertilized control in red basil cultivation. Microbial consortia have also been studied for their impact on soil physicochemical properties and nutrient status. Kavya et al. (2020) reported that microbial consortia improved soil physicochemical properties with decreased doses of chemical fertilizers. Additionally, Fathallah et al. (2021) investigated the use of natural and bio-fertilizers on Balady mandarin trees, showing that organic and biofertilizers could potentially reduce the need for mineral fertilizers. Niedziński et al. (2021) evaluated the release patterns of nitrogen from different types of fertilizers and their impact on soil chemical parameters, noting significant changes in soil nitrogen content with mineral fertilizers but not with organic fertilizers. This highlights the importance of understanding the effects of different fertilizers on soil chemistry. Overall, the literature suggests that organic fertilizers can play a crucial role in improving soil fertility, nutrient content, and soil organic carbon turnover rates. Further research is needed to explore the long-term effects of organic fertilizers on soil properties and crop yields, as well as to optimize the use of organic fertilizers in agricultural practices.

This research aims to study the chemical content and composition of organic fertilizers and inorganic fertilizers used locally by farmers in Tarragon region in southern Libya, to compare the compositional content of fertilizers and their suitability to nutritional requirements necessary for crop growth.

MATERIALS AND METHODS

Sample collection and Preparation:

Three types of organic fertilizers were collected from local farms in tarragon- Libya, and three locally chemical fertilizers were collected based on their availability and popularity among the farmers. The organic fertilizers samples were taken by Identify homogeneous areas in each barn and take a quantity of the sample with a depth of 2 cm , dried and grind then place it in a glass container. The commercial fertilizers samples were taken directly from the package into in a glass container. and labelled as shown in table (1) :

Table (1): The studied fertilizer samples

Key	Type of Fertilizer	Sample
A	Organic	Sheep manure
B	Organic	Chicken manure
C	Organic	Pigeon manure
D	Inorganic	SULOTASTE Fertilizer
E	Inorganic	Compound Fertilizer
F	Inorganic	MONOAMMONIOM PHOSPHATE Fertilizer

Determination of Chemical Content :

Humidity Estimation:

The moisture content of fertilizers was estimated by taking a specific weight of the sample powder and placing it in a crucible in a drying oven at 105ºC for 4 hours, the left to cool in desiccator and weighted to calculate the moisture percentage by the following equation:

$$\textbf{Moisture}\ \% = \frac{\textbf{Wt of sample } - [\textbf{Wt of dry sample}]}{\textbf{Wt of sample}}\ \textbf{x 100} \quad \textbf{Eq. 1}$$

Ash Estimation:

A specific amount of fertilizer sample was weighted in a crucible and placed in a burning oven at 600ºC for 3 hours, after completing burning, the crucible is cooled for 20 minutes and weighted to calculate the amount and percentage of ash in samples using the following equation:

% Ash = Wt of crucible after burning - Wt of crucible before Eq.2

$$\text{Ash}\ \% = \frac{\text{amount of Ash}}{\text{Wt of sample}} \times 100 \quad Eq.3$$

Protein Estimation:

Protein was estimated in the studied fertilizer samples according to Keldahl method by taking 10ml of the fertilizer sample extract into a conical flask, adding1ml of phenolphthalein, then 0.4ml of a saturated solution of potassium oxalate $(COOK)_2.H_2O)$, and leave it for two minutes. The solution then titrated to pink by NaOH (0.1M), then 2ml of 40% formaldehyde solution (which was previously modified by the presence of phenolphthalein with sodium hydroxide NaOH). Continue the titration to the same pink point that was previously obtained.

Protein ratio =1.7 × Volume of NaOH solution from burette Eq.4

Where: 1.7 is an approximate constant for matching the test result with the Keldahl method.

X-Ray Fluorescence (XRF) Analysis:

Estimation of chemical content using (NEX-QC) Energy Dispersive X-ray Fluorescence (EDXRF) for non-destructive elemental analysis of sodium (Na) through uranium (U) depending on setup, for all studied samples of fertilizers.

RESULTS AND DISCUSSION

Table (2) and Figure (1) shows the initial chemical properties of the studied samples of fertilizers.

Table (2): The Initial properties of Studied Fertilizers:

Sample	Moisture %	Ash %	Protein %
A	20	34	12.75
B	4	34	14.11
C	4	50	15.98
D	20	34	19.38
E	20	10	31.14
F	20	92	12.6

Moisture Estimation:

As shown in table 2 the average percentage of moisture in fertilizers 20%, with the exception of sample B (Chicken manure) and C (Pigeon manure) which was 4% as the lowest, as shown in figure 1 below.

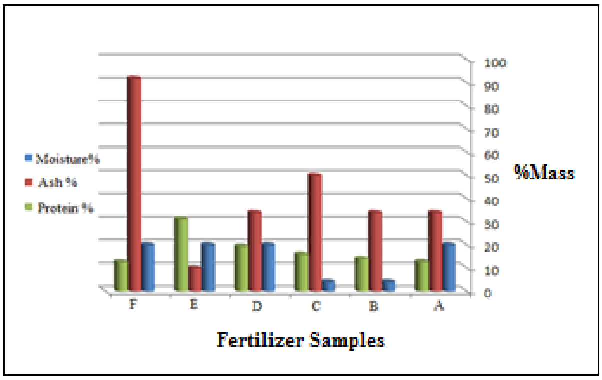

Figure (1): Moisture, Ash, and Protein Content in Studied Fertilizers

Ash Estimation:

The Ash content in studied fertilizers vary from 10% in sample E to 92% in sample F. where noted that the organic fertilizers has a similar amount of carbon content compared to chemical fertilizers.

Protein Estimation:

The amount of Protein in the studied samples ranged between 12.75% in sample A to 31.14% in sample E (Compound fertilizer) which was the highest protein content fertilizer.

XRF Analysis:

The results of XRF analysis shown in Table (3). Showed a large variation in the percentages of chemical elements and minerals in the studied fertilizers samples.

Table (3): XRF analysis of the studied Fertilizers:

	Mass %					
	A	**B**	**C**	**D**	**E**	**F**
P	2.89	4.36	3.49	4.47	6.10	65.2
K	9.42	17.3	12.4	-	60.7	1.54
Ca	34.1	16.5	22.8	14.8	2.67	5.32
Si	23.8	21.2	30.1	26.2	3.39	2.68
S	3.93	6.20	3.38	4.36	14.4	11.1
Al	5.45	6.35	6.33	15.7	2.38	2.60
Fe	5.49	6.94	6.45	6.38	0.924	2.67
Cl	4.81	11.2	6.50	5.24	1.48	2.25
Ni	0.509	0.538	0.420	3.89	0.172	0.344
Zn	0.234	0.244	0.197	0.668	0.161	0.637
Mn	0.444	0.366	0.273	-	0.366	0.0949
Co	0.134	0.138	0.117	0.624	0.0499	0.0683
Cu	0.195	0.188	0.140	1.19	0.115	0.128
I	0.706	0.737	0.579	-	-	0.239
Mg	-	-	-	-	2.73	-
Ti	-	1.18	1.30	-	-	-
Sn	-	2.07	1.46	-	3.56	-
Ba	1.19	0.149	0.387	-	-	-
Te	2.17	2.39	1.58	6.27	0.574	1.68
As	0.0137	0.0167	0.0038	0.0888	0.0056	0.0259
Sb	<0.0001	0.433	0.182	7.33	0.148	0.632

As the percentage of phosphorus, potassium, and calcium ranged from 2.89 in sample A to 65.2 in sample F for phosphorus. As for potassium, the highest value was 60.7 in sample E, while the lowest value was 1.54 in sample F. While sample D was devoid of potassium.

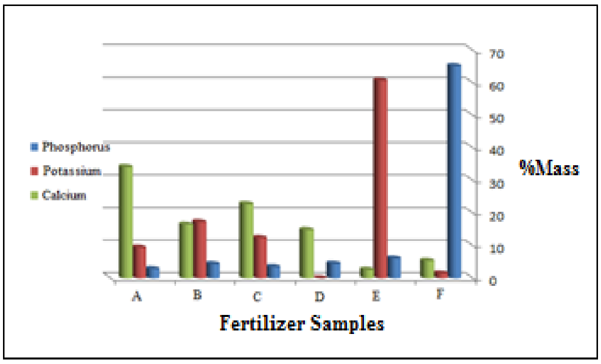

Figure (2): P, K, and Ca Content in Studied Fertilizers

The results also showed that organic fertilizers contain high levels of calcium, the highest being in sample A 34.1, as shown in Figure 2 below.
While the concentrations of silicon were the highest in sample C, which is similar to the rest of the organic fertilizer and compound fertilizer samples D. As shown in Figure (3).

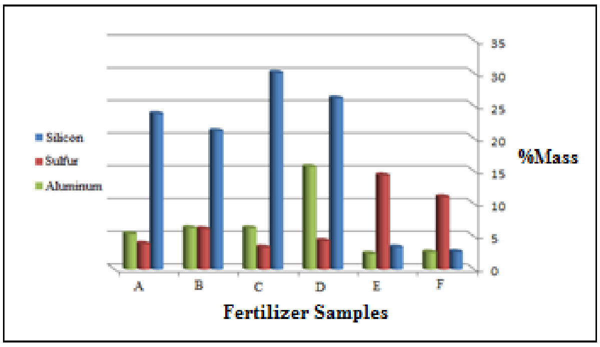

Figure (3): Si, S, and Al Content in Studied Fertilizers

As for sulphur, organic fertilizers were characterized by moderate percentages of it, ranging from 3.3 to 6.2. While the highest percentage in sample E was in inorganic fertilizers. Figure .3 also shows that organic fertilizers are richer in aluminium.

Iron concentrations in the studied fertilizers ranged from 2.67 to 6.94, as organic fertilizers contained higher iron percentages than manufactured fertilizers. As shown in Figure 4. also sample B (chicken manure) contains a high percentage of chloride.

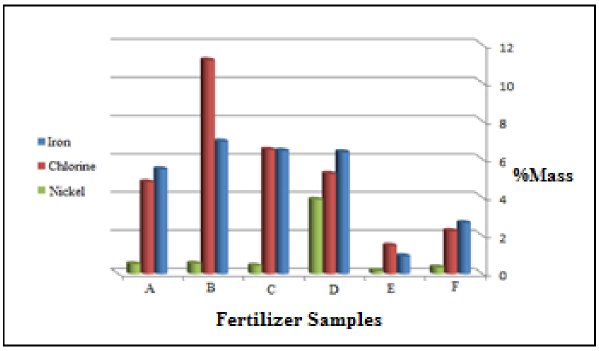

Figure (4): Fe, Cl, and Ni Content in Studied Fertilizers

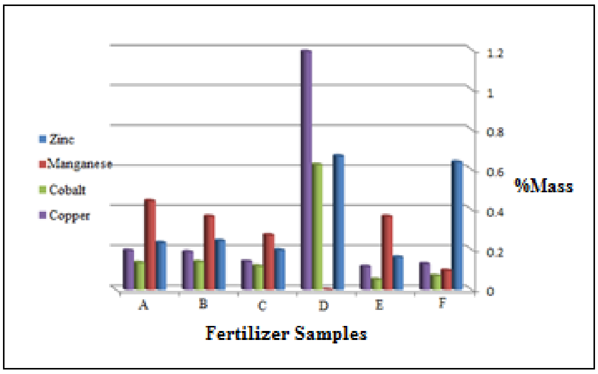

Figure (5): Zn, Mn, Co, and Cu Content in Studied Fertilizers

As for other elements, such as zinc, manganese, cobalt, and copper, the percentages were very close in organic fertilizers and different in manufactured fertilizers, as in Figure (5).

Discussion

The presence of trace elements such as zinc, manganese, cobalt, and copper in organic fertilizers plays a crucial role in influencing soil characteristics and crop yield. Wyszkowski et al. (2020) found that nitrogen fertilization increased the contents of zinc, copper, manganese, and cobalt in agricultural soil, highlighting the importance of these elements in plant growth. Additionally, the study by Page-Karjian et al. (2020) revealed that bottlenose dolphins had higher concentrations of zinc compared to other contaminants, indicating the significance of this trace element in marine ecosystems. Furthermore, the research conducted by Wyszkowski et al. (2022) demonstrated that the application of organic materials reduced the content of manganese, zinc, iron, and cobalt in maize plants, emphasizing the potential of organic fertilizers in mitigating the adverse effects of nitrogen. This aligns with the findings of Beesigamukama et al. (2022), who highlighted the nutrient concentrations and fertilizing indices of insect frass fertilizers as promising alternatives for improving soil health and crop yield. Moreover, Gledhill et al. (2022) investigated the trace metal stoichiometry of dissolved organic matter in the Amazon plume, including elements such as zinc, cobalt, and manganese. This study underscores the intricate relationship between dissolved organic matter and trace metals in aquatic environments, further emphasizing the importance of these elements in nutrient cycling.
Overall, the literature suggests that zinc, manganese, cobalt, and copper in organic fertilizers play a significant role in influencing soil properties, plant growth, and ecosystem health.
Silicon, sulphur, aluminum, and iron are essential elements in organic fertilizers that play a crucial role in plant growth and development. Silicon fertilizers derived from various organic sources have been shown to alleviate environmental stressors and improve plant health (Shaida et al., 2021). Additionally, the presence of silicon and calcium in soil can impact the mobility of iron and aluminum, affecting their availability for plant uptake. Sulphur is commonly used in the production of sulfuric acid for sulfate and phosphate fertilizers, highlighting its commercial importance in agriculture (Sulfur – Wikipedia, 2023). Furthermore, the variability of the composition of sewage sludge, which may contain sulphur, has been studied to determine its physical and chemical properties for potential use as a fertilizer (Kiper et al., 2019). Aluminum, another important element in organic fertilizers, can form complexes with organic compounds and hydrated aluminum oxide, contributing to the overall nutrient content of the soil. Additionally, aluminum silicate with iron can be found in minerals and ores, highlighting its presence in the environment and potential impact on plant growth. Iron, a crucial micronutrient for plant growth, can be found in guano along with other elements such as aluminum, calcium, and phosphorous, emphasizing its importance in organic fertilizers. Furthermore, iron content in soil can be measured using soil testing methods to ensure proper nutrient levels for plant growth. In conclusion, the presence of silicon, sulphur, aluminum, and iron in organic fertilizers plays a significant role in plant nutrition and growth. Understanding the properties and interactions of these elements in soil and fertilizers is essential for sustainable agriculture practices and maximizing crop yields.

CONCLUSION

Based on the analyses conducted on samples of organic and inorganic fertilizers in this study, as well as previous results, it is evident that organic fertilizers are rich in minerals that provide benefits to both the soil and plants. In comparison to inorganic fertilizers, organic fertilizers contain higher levels of elements including Ca, Si, Al, Fe, Cl, Mn, I, Ti, and Te. They also have moderate levels of S, Co, and Cu, while maintaining low levels of toxic elements such as As and Sb.

REFERENCES

Alnhoud. O. T.; A. M. Al-Harahsheh; M. S. Al-Harahsheh; F. Irshaid Irshaid;(2021). Animal Solid Waste As A Potential Renewable Biomass Energy Source: A Case Study of Jordan, BIOMASS CONVERSION AND BIOREFINERY, Vol.13, pp:6807-6816.

Beesigamukama D. ; S. Subramanian; C. M Tanga; (2022). Nutrient Quality and Maturity Status of Frass Fertilizer from Nine Edible Insects, SCIENTIFIC REPORTS, 12 (1), 7182.

Cihangir. H; A. Oktem; (2019). The Effect of Different Organic Nutrients on Some Quality Properties of Popcorn (Zea Mays L. Everta), ASIAN FOOD SCIENCE JOURNAL. 7 (2), 1-9.

Corguinha, A.P.B.; G.A. de Souza; V.C. Gonçalves; C.A. Carvalho; W.E.A. de Lima; F.A.D. Martins; H.C. Yamanaka; E.A.B. Francisco; and L.R.G. Guilherme (2015). Assessing arsenic, cadmium, and lead contents in major crops in Brazil for food safety purposes. J. Food Compos. Anal. 37, 143–150.

Domingues R.; P. F Trugilho; C. A Silva; I. Cristina N A de Melo; Leônidas C A Melo; Zuy M Magriotis; Miguel A Sánchez-Monedero; (2017). Properties Of Biochar Derived From Wood And High-nutrient Biomasses With The Aim Of Agronomic And Environmental Benefits, PLOS ONE, 12 (5), e0176884.

Epule. E. T.; C. R . Bryant; C. Akkari; and O. Daouda (2015). Can organic fertilizers set the pace for a greener arable agricultural revolution in Africa? Analysis, synthesis and way forward, Land Use Policy, vol. 47, pp. 179–187.

Fathallah A. M.; A. E. Hasan; A. A. Kasem; Basma S. A. Salama; (2021). THE BENEFICIAL EFFECTS OF FERTILIZERS BY USING NATURAL AND BIO-FERTILIZERS ON VEGETATIVE GROWTH AND FRUITING OF BALADY MANDARIN, MENOUFIA JOURNAL OF PLANT PRODUCTION, 6 (8), 405-422.

Gledhill M.; A. Hollister; M. Seidel; K. Zhu; E. P Achterberg; T. Dittmar; A. Koschinsky; (2022). Trace Metal Stoichiometry of Dissolved Organic Matter in The Amazon Plume, SCIENCE ADVANCES, 8 (31), eabm2249.

Hafez. M; A. I. Popov; and M. Rashad (2021). Integrated use of bioorganic fertilizers for enhancing soil fertility–plant nutrition, germination status and initial growth of corn (Zea Mays L.), Environmental Technology & Innovation, vol. 21, Article ID 101329.

He, R.; C. Shao; R. Shi; Z. Zhang; and R. Zhao (2020). Development Trend and Driving Factors of Agricultural Chemical Fertilizer Efficiency in China. Sustainability, 12, 4607.

Isa .A; Safari M.; Hadawi I.;(2021). Effects of Different Organic Manures and Chemical Fertilizers on Yield and Yield Component of Olive (Olea Europaea L.,) Cv Zard In Kermanshah Province, Agrotechniques in Industrial Crops 1 (2), 61-70.

Iqbal, A.; L. He; I. Ali; S. Ullah; A. Khan; K. Akhtar; S. Wei; Q. Zhao; J. Zhang; et al. (2020). Manure combined with chemical fertilizer increases rice productivity by improving soil health, post-anthesis biomass yield, and nitrogen metabolism. PLoS ONE, 15, e0238934.

Jahan .M.; M. J. Kondori; (2006). THE EFFECTS OF CHEMICAL AND ORGANIC FERTILIZERS ON SAFFRON FLOWERING, II International Symposium on Saffron Biology and Technology 739, 81-86.

Kanda, M.; G. Djaneye-boundjou; K. Wala; et al., (2015). World's largest science, technology & medicine open access book publisher advances in analytical methods for organophosphorus pesticide detection, Environmental Systems Research, vol. 5, no. 5, pp. 36–42.

Kavya Y.; N. Trimurtulu; A. Vijaya Gopal; P. Madhu Vani; N. V. V. S. D. Prasad; (2020). Effect of Inoculation of Microbial Consortia on Soil Physicochemical and Nutrient Status, CURRENT JOURNAL OF APPLIED SCIENCE AND TECHNOLOGY.

Khalid . Kh.A., & Shafei. A. M. (2005). Productivity of Dill (Anethum Graveolens L.) As Influenced By Different Organic Manure Rates and Sources,

ARAB UNIVERSITIES JOURNAL OF AGRICULTURAL SCIENCES, 13 (3), 901-913.

Kiper J.; A. Głowacka; T. Rucińska; (2019). Analysis of The Variability of The Composition of Sewage Sludge Before and After Drying Treatment – SEM Studies, JOURNAL OF ECOLOGICAL ENGINEERING, 20 (7), 45-52.

Li, S. ; Y. Zhang; D. Nadolnyak; J.D. Wesley; and Y. Zhang (2014). Fertilizer industry subsidies in China: Who are the beneficiaries? China Agric. Econ. Rev., 6, 433-451..

Liu, Y.; L. Zou; Y. Wang (2020). Spatial-temporal characteristics and influencing factors of agricultural eco-efficiency in China in recent 40 years. Land Use Policy, 97, 104794.

Mubarak. A. R.; E. A. M. Gali; A. G. Mohamed; D. Steffens; A. H. Awadelkarim; (2010). Nitrogen Mineralization from Five Manures As Influenced By Chemical Composition and Soil Type, COMMUNICATIONS IN SOIL SCIENCE AND PLANT ANALYSIS, 41 (16), 1903-1920.

Majee. S.; G. Halder; D.D. Mandal; O. N. Tiwari; and T. Mandal (2021). Transforming wet blue leather and potato peel into an eco-friendly bio-organic NPK fertilizer for intensifying crop productivity and retrieving value-added recyclable chromium salts, Journal of Hazardous Materials, vol. 411, Article ID 125046.

Morari, F.; G. Vellidis; and P. Gay (2011). Nitrogen Cycle, Fertilizers, and N Loss Pathways.

Moreno-Caselles .J; Raul Moral; M. D. Pérez-Murcia; Aurelia Perez-Espinosa; B. Rufete;. (2002). NUTRIENT VALUE OF ANIMAL MANURES IN FRONT OF ENVIRONMENTAL HAZARDS, COMMUNICATIONS IN SOIL SCIENCE AND PLANT ANALYSIS, 33 (15-18), 3023-3032.

Naila, A.; G. Meerdink; V. Jayasena; A.Z. Sulaiman; A.B. Ajit; and G. Berta (2019). A review on global metal accumulators—Mechanism, enhancement, commercial application, and research trend. Environ. Sci. Pollut. Res., 26, 26449–26471.

Niedziński T.; M. J. Sierra; J. Łabętowicz; K. Noras; C. Cabrales; R. Millán; (2021). Release of Nitrogen from Granulate Mineral and Organic Fertilizers and Its Effect on Selected Chemical Parameters of Soil, AGRONOMY, 11 (10), 1981.

Page-Karjian A. ; Catherine F. Lo; B. Ritchie; C. Harms; D. Rotstein; Sushan Han; S. Hassan; A. Lehner; J. Buchweitz; V. Thayer; Jill M. Sullivan; E. Christiansen; Justin R. Perrault; (2020). Anthropogenic Contaminants and Histopathological Findings in Stranded Cetaceans in The Southeastern United States, 2012–2018, FRONTIERS IN MARINE SCIENCE, 7, 630.

Qin, G.; Z. Niu; J. Yu; Z. Li; J. Ma; and P. Xiang (2020). Soil heavy metal pollution and food safety in China: Effects, sources and removing technology. Chemosphere, 267, 129205.

Sarwar. M. ; J. K. Patra ; A. Ali; M. Maqbool; and M. I. Arshad (2021). Effect of compost and NPK fertilizer on improving biochemical and antioxidant properties of Moringa oleifera, South African Journal of Botany, vol. 129, pp. 62-66,.

Singh T. B.; A. Ali; M. Prasad; A. Yadav; P. Shrivastav; D. Goyal; P. K. Dantu; (2020). Role of Organic Fertilizers in Improving Soil Fertility, Conttaminants in agriculture: sources, impacts and management, 61-77.

Shahena, S. ; M. Rajan; V. Chandran; and L. Mathew (2021). Conventional methods of fertilizer release, in Controlled Release Fertilizers for Sustainable Agriculture Elsevier, Amsterdam, Netherlands, 1-24.

Shaji, H. ; V. Chandran; and L. Mathew (2021). Organic fertilizers as a route to controlled release of nutrients, in Controlled Release Fertilizers for Sustainable Agriculture, 231-245, Elsevier, Amsterdam, Netherlands.

Shaida M. A.; R K Dutta; A K Sen; S S Ram; M Sudarshan; Mu Naushad; Grzegorz Boczkaj; Md Sadique Nawab; (2021). Chemical Analysis of Low Carbon Content Coals and Their Applications As Dye Adsorbent, CHEMOSPHERE, 287, 132286.

Shi. S; Wang. X.; Ye Zh.; Chen W.; T. Li; J. Chen; Ji. Li; (2019). Effect Of The Combined Application Of Fungal Residue And Chemical Fertilizers On The Mineralization Of Soil Organic Carbon In Paddy Fields, ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH, 26, 23292-23304.

Teliban G.; V. Stoleru; M. Burducea; A. Lobiuc; N. Munteanu; L. Popa; Gianluca Caruso; (2020). Biochemical, Physiological and Yield Characteristics of Red Basil As Affected By Cultivar and Fertilization, AGRICULTURE, 10 (2), 48.

World Bank, (2006). Factors Affecting Supply of Fertilizer in Sub-Saharan Africa. Transport, World Bank, Washington, DC, USA.

Wu. J; A. Sharaf; J. Sun; X. Qu; (2019). Effects Of Organic Wastes On Structural Characterizations Of Fulvic Acid In Semiarid Soil Under Plastic Mulched Drip Irrigation, CHEMOSPHERE, 234, 830-836.

Wyszkowski M.; M. S. Brodowska; (2020). Content of Trace Elements in Soil Fertilized with Potassium and Nitrogen, AGRICULTURE, 10 (9), 398.

Zou, L.; Y. Liu; Y. Wang; and X. Hu (2020). Assessment and analysis of agricultural non-point source pollution loads in China: 1978–2017. J. Environ. Manag. 263, 110400.