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The Aftermath Of Diapers Absorbents On Soil Physio-Chemical Properties And Its Influence On The Performance Of Crops (Maize) Yield In Obubra Local Government Area Of Cross River State, Nigeria.

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Abstract
This study investigates the environmental impacts of disposable diaper absorbents on soil physico-chemical properties and their subsequent effects on maize (Zea mays L.) yield in Obubra Local Government Area, Cross River State, Nigeria. The increasing use of disposable diapers, particularly in regions with inadequate waste management, poses significant challenges to soil health due to the non-biodegradable nature of superabsorbent polymers (SAPs) and other materials contained within these products.
We conducted a controlled experiment on sandy soil, analyzing various treatments with different levels of diaper absorbents (0g, 40g, 80g, 120g, 160g, and 200g per 10kg of soil). Soil samples were collected and subjected to standard physico-chemical analyses, including texture, pH, organic matter content, and nutrient availability.
Our findings reveal that moderate levels of diaper absorbents can maintain beneficial sand content while increasing silt levels, which may enhance soil fertility and moisture retention. However, excessive application (beyond 80g) leads to diminished sand percentages and potential long-term soil health issues, such as reduced aeration and root growth inhibition. The pH of the soil across treatments ranged from 6.26 to 6.88, indicating a generally favorable environment for maize cultivation.
This research highlights the need for sustainable waste management strategies to mitigate the adverse effects of disposable diaper waste on agricultural land. By providing insights into the complex interactions between diaper absorbents and soil properties, our findings contribute to the broader discourse on agricultural sustainability and environmental health in developing regions. Further studies are recommended to explore the long-term ecological implications of diaper absorbents in agricultural contexts.

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I. Introduction:

The increasing use of disposable diapers has led to a significant environmental challenge, particularly in areas with inadequate waste management systems, such as Obubra Local Government Area (L.G.A.) of Cross River State, Nigeria. Disposable diapers are primarily composed of superabsorbent polymers (SAPs), which are designed to absorb and retain large quantities of liquid. These polymers, along with other components such as cellulose fibers and plastics, are not biodegradable and can persist in the environment for extended periods (Rothrock *et al*., 2013). The improper disposal of these materials can have far-reaching effects on soil physio-chemical properties and, consequently, on agricultural productivity.

Soil is a fundamental resource in agriculture, and its health is critical for crop yield. Key soil properties, including pH, nutrient content, moisture retention, and microbial activity, are crucial for plant growth and development (Brady & Weil, 2010). The introduction of non-biodegradable materials from used disposable diapers into the soil may alter these properties, potentially affecting crop performance. In particular, maize (Zea mays L.), a staple crop in Obubra L.G.A., could be impacted by changes in soil conditions resulting from diaper waste contamination.

Previous studies have indicated that the presence of superabsorbent polymers in soil can influence water retention capacity, which may have both positive and negative implications for crop yield depending on the context (Bai *et al.,* 2010). On one hand, enhanced moisture retention could benefit crops during dry periods (Johnson *et al*., 2012). On the other hand, the accumulation of non-biodegradable materials could disrupt soil structure, reduce aeration, and hinder root growth, ultimately leading to reduced crop performance (Liang *et al*., 2014).

In Obubra L.G.A., where agriculture forms the backbone of the local economy, understanding the impact of diaper waste on soil and crop productivity is essential. This study aims to investigate the effects of used disposable diapers on soil physio-chemical properties and their subsequent influence on maize yield. By examining soil samples from fields with varying levels of diaper contamination, the research seeks to provide insights into the extent of the impact and offer recommendations for mitigating negative effects. The findings will contribute to the broader discourse on sustainable waste management practices and their implications for agricultural sustainability in developing regions.

Through a comprehensive analysis of soil properties and maize performance, this study will address critical questions about the long-term consequences of disposable diaper waste on agricultural land. It will also highlight the need for improved waste management strategies to safeguard soil health and ensure food security in Obubra L.G.A. and similar contexts globally.

II. Methodology

Study Design

This study aims to evaluate the environmental impacts of different levels of diaper absorbents on the physical fertility status of a typical sandy soil. The experiment was conducted in a controlled environment to ensure accurate and reliable results.

Site Selection and Soil Sampling

Site Selection: The experiment was conducted in 2024 on a typical sandy soil site within the Teaching and Research farm of Department of Agronomy, Faculty of Agriculture and Forestry, University of Cross River State, Nigeria (6.8^{o}N, 8.20^{o}E). The soil of the experimental site is classified as Ultisols, Periaway *et. al.,* (1983). The area is a tropical rain forest. The mean annual rainfall ranges from 2000mm to 2500mm (CRADP, 1992).

Soil Sampling: Soil samples were collected from each of the treatments and the samples were air-dried, sieved with a (2 mm) merge sieve, and taken to National Soil, Plant, Fertilizer and Water Laboratories Umudike Abia State for analysis.

Experimental Setup

Treatments, Replication and Application of Diaper Absorbents

The experiment included several treatments with varying levels of diaper absorbents (0g/10kg, 40g/10kg, 80g/10kg, 120g/10kg, 160g/10kg and 200g/10kg of soil). A control treatment with no diaper absorbent was included for comparison. Each treatment was replicated five times to ensure statistical validity. Commercially available diaper absorbents was used, primarily consisting of superabsorbent polymers (SAPs). The absorbents was mixed thoroughly with the soil samples to ensure uniform distribution.

Physio-Chemical Analysis of soil:

Soil Texture: The hydrometer method was used (Gee & Bauder, 1986) to determine the soil texture.

pH Measurement: Soil pH was measured in water (1:1 ratio) using a pH meter (McLean, 1982) in the laboratory.

Organic Matter Content: Organic matter content was determined using the Walkley-Black method (Walkley & Black, 1934)

Nutrient Analysis: Macronutrients (N, P, K) and Micronutrients were analyzed in the laboratory using standard methods (Hanlon *et. al*., 1998)

Plant dry weight: The plants dry matter weights were taken at 8 weeks after planting.

Data Analysis: all data acquired were subjected to Analysis of Variance (ANOVA) to distinguish treatment differences.

III. Results And Discussion:

Effects of Diaper Absorbents on Soil Particle Size Distribution (Sand, Silt and Clay Content) and its implications for Soil Health and Crop Yield.

The results as presented in Table 1 illustrate the impact of varying levels of diaper absorbents on the particle size distribution of soil, specifically focusing on the percentages of sand, silt, and clay. Understanding these changes is crucial for assessing the potential implications on soil health and agricultural productivity, particularly in the context of maize cultivation in Obubra Local Government Area, Cross River State, Nigeria.

The control treatment (0g absorbent) shows the highest sand content at 74.10%, which is significantly greater than that observed in the 40g treatment (71.60%). Interestingly, the 80g treatment (74.60%) also yielded a high sand percentage, comparable to the control. However, the introduction of absorbents at higher levels (120g, 160g, and 200g) resulted in sand percentages that were not significantly different from each other, ranging from 72.10% to 72.60%. This suggests that while moderate levels of absorbents can maintain sand proportions, excessive application may stabilize or slightly reduce sand content.

The silt content exhibited notable variation across treatments. The 120g absorbent treatment had the highest silt percentage (23.40%), significantly differing from the 40g treatment (21.40%) and the control

(17.90%). This increase in silt could be beneficial, as higher silt content may enhance soil fertility and moisture retention. Conversely, the clay content across all treatments remained relatively low, with no significant differences detected (ranging from 4.00% to 8.00%). This consistent clay level indicates that diaper absorbents do not significantly alter this aspect of soil texture.

The Least Significant Difference (LSD) values provided (2.68 for sand, 5.13 for silt, and 4.64 for clay) indicate the thresholds for significance among treatments. The presence of overlapping letters in the results signifies that certain treatments yield similar outcomes, reinforcing the idea that moderate absorbent levels can sustain soil texture without detrimental effects.

The findings from Table 1 suggest that the application of diaper absorbents can influence soil particle size distribution, particularly in terms of silt content, which may affect the soil's overall fertility and its capacity to retain moisture. The maintenance of sand content across treatments is promising for the physical structure of the soil, potentially facilitating good drainage and root development.

However, the implications for maize yield hinge on a delicate balance. While improved moisture retention from increased silt may benefit crop growth, excessive reliance on non-biodegradable materials could lead to long-term soil health issues, such as reduced aeration and root penetration. Consequently, while the immediate effects of diaper absorbents on soil texture appear manageable, careful consideration of their long-term impacts on soil health and agricultural sustainability is warranted.

In conclusion, further research is essential to explore the broader ecological implications of introducing diaper absorbents into agricultural soils, particularly in regions similar to Obubra L.G.A., where agricultural practices are critical for local economies.

Effects of Diaper Absorbents on Soil Basic Nutrients

Table 2 provides insights into the impact of different levels of diaper absorbents on essential soil nutrients and pH, crucial for understanding the potential implications on soil health and agricultural productivity, particularly in the context of maize cultivation in Obubra Local Government Area, Cross River State, Nigeria.

pH Levels

The pH values ranged from 6.26 to 6.88 across the treatments. The control treatment displayed the lowest pH at 6.26, while the highest pH of 6.88 was observed in the 160g absorbent treatment. The variation in pH levels suggests that the introduction of diaper absorbents may influence soil acidity, potentially affecting nutrient availability and plant growth.

Nitrogen, Phosphorus, Potassium Organic Carbon and Organic matter Content

Nitrogen levels exhibited significant variability among treatments. The control treatment recorded the highest nitrogen content at 0.16%, while the 120g absorbent treatment showed the lowest nitrogen level at 0.12%. The decrease in nitrogen content with increasing absorbent levels implies that higher concentrations of diaper materials may negatively impact nitrogen retention or availability in the soil, which is vital for optimal plant growth and development.

Phosphorus content showed a notable decline from the control treatment (12.55 mg/kg) to the 40g absorbent treatment (9.50 mg/kg), with no significant differences among the higher absorbent treatments. The reduction in phosphorus availability across treatments could potentially hinder plant growth and development, as phosphorus plays a critical role in root development and energy transfer within plants.

Potassium levels varied significantly among treatments, with the 80g absorbent treatment recording the highest potassium content at 0.20 cmol/kg, while the 160g and 200g treatments exhibited the lowest potassium levels at 0.14 cmol/kg. This fluctuation suggests that moderate levels of diaper absorbents may enhance potassium availability in the soil, while excessive application could potentially lead to nutrient imbalances that may affect plant health and growth.

The levels of organic carbon and organic matter displayed a general decline with increasing levels of diaper absorbents. The control treatment exhibited the highest organic carbon (1.78%) and organic matter (3.07%), whereas the 160g absorbent treatment showed the lowest values at 1.38% and 2.39%, respectively. The decrease in organic matter is particularly concerning, as it is essential for maintaining soil structure, nutrient retention, and microbial activity, all of which are critical for sustaining healthy crop production.

The Least Significant Difference (LSD) values provided in the statistical analysis indicate the thresholds for statistical significance among treatments for pH (0.17), nitrogen (0.02), phosphorus (0.45), potassium (0.004), organic carbon (0.08), and organic matter (0.13). These values help in interpreting the variability in nutrient levels and emphasize the impact of diaper absorbents on soil properties.

The findings from Table 2 underscore the significant influence of diaper absorbents on soil pH and nutrient dynamics. While some treatments showed potential benefits in enhancing potassium availability, the overall trends suggest a concerning decline in essential nutrients such as nitrogen and phosphorus, along with a reduction in organic matter content.

Effects of varying levels of diaper absorbents on Soil Exchangeable Aluminum (EA) and Cation Exchange Capacity (ECEC)

The results presented in Table 3 illustrate the effects of varying levels of diaper absorbents on soil exchangeable plant nutrients, which are critical for assessing soil fertility and crop performance in the context of agricultural sustainability.

The data indicate a significant variation in exchangeable aluminum (EA) and cation exchange capacity (ECEC) across the different treatments. The control treatment (0g absorbent) exhibited the highest EA (0.66 cmol/kg), while the highest level of diaper absorbent (80g) resulted in the lowest EA (0.76 cmol/kg). This suggests that the introduction of superabsorbent polymers may alter the binding dynamics of soil nutrients, potentially affecting nutrient availability for maize crops. The ECEC values also varied significantly, with the 80g treatment yielding the highest value (9.83 cmol/kg), indicating enhanced nutrient holding capacity, which can be beneficial for crop growth.

Effects of varying levels of diaper absorbents on Calcium (Ca), Magnesium (Mg) availability and Base Saturation (BS)

Calcium (Ca) levels were highest in the 80g absorbent treatment (6.20 cmol/kg), while lower levels were observed in the 0g and 40g treatments (5.80 cmol/kg and 5.40 cmol/kg, respectively). The availability of magnesium (Mg) showed an interesting trend, with the 40g treatment displaying the highest Mg concentration (3.40 cmol/kg). The shifts in Ca and Mg availability highlight the complex interactions between soil amendments and nutrient dynamics, emphasizing the need for careful management of diaper absorbent applications to optimize soil fertility.

Base saturation percentages were highest in the 40g treatment (94.95%), indicating a favorable nutrient environment for plant growth. In contrast, the 160g treatment had the lowest base saturation (92.24%), which may suggest that higher levels of diaper absorbents could impede nutrient availability or alter soil chemistry in ways that affect nutrient uptake.

The findings from Table 3 underscore the nuanced impacts of diaper absorbents on soil nutrient exchange dynamics. While certain levels of diaper absorbents can enhance cation exchange capacity and specific nutrient availabilities, excessive amounts may lead to imbalances that could adversely affect crop performance. These results highlight the importance of optimizing diaper absorbent applications to maintain soil health and productivity, particularly in regions reliant on agriculture as a primary economic activity. Future research should explore the long-term implications of these findings on crop yield and soil sustainability.

Impact of Diaper Absorbents on Maize Yield

Table 4 presents the effects of varying levels of diaper absorbents on maize yield, measured as dry matter weight at 8 weeks after planting. The treatments ranged from 0g to 200g of absorbent per 10kg of soil.

The maize yield showed a variable response to the different levels of diaper absorbents. Initially, as the absorbent level increased from 0g to 80g, there was a noticeable improvement in dry matter weight. This suggests that moderate levels of absorbents may enhance moisture retention, benefiting crop growth during the early weeks. Beyond 80g, however, the yield began to decline. This reduction in yield could be due to the excessive presence of superabsorbent polymers, which might disrupt soil structure, reduce aeration, or hinder root development.

The data indicate that the 80g absorbent level was the most beneficial for maize yield, possibly due to improved soil moisture conditions without adverse effects on soil structure or nutrient availability. The control treatment (0g absorbent) had lower yields compared to the optimal absorbent level (80g), highlighting the potential benefit of using diaper absorbents in moderation to improve crop performance under specific conditions. At higher levels (120g and above), the yield decrease suggests that the negative impacts of excessive absorbents outweigh the benefits of increased moisture retention. This could be due to factors such as reduced soil aeration and nutrient uptake efficiency.

The application of diaper absorbents in soil has a nuanced impact on maize yield. Moderate levels can enhance crop performance by improving moisture retention, while excessive amounts may lead to negative outcomes. These findings underscore the importance of determining optimal application rates to maximize benefits and minimize potential drawbacks. Further research could explore long-term effects and the interaction with different soil types to refine these recommendations.

IV. Summary:

This study examined the effects of disposable diaper absorbents on soil physio-chemical properties and maize crop yield in Obubra Local Government Area, Cross River State, Nigeria. The research highlighted significant findings regarding the impact of superabsorbent polymers (SAPs), commonly found in diapers, on soil texture, nutrient content, and crop performance.

The study revealed variations in soil particle size distribution with different levels of diaper absorbents. Moderate levels showed a stable sand content, while higher levels slightly reduced sand proportion. Silt content increased with higher absorbent levels, potentially enhancing soil fertility and moisture retention. The presence of diaper absorbents influenced basic soil nutrients and pH levels. The pH ranged from 6.26 to 6.88, with the highest pH observed in higher absorbent treatments, indicating potential alterations in soil acidity.

The study suggested that while increased silt content from absorbents might improve moisture retention, excessive non-biodegradable materials could disrupt soil structure, affecting aeration and root growth. This balance is crucial for sustaining maize yield.

V. Conclusion:

The introduction of diaper absorbents into agricultural soils can have both beneficial and detrimental effects on soil health and crop productivity. While moderate levels of absorbents may enhance certain soil properties, excessive use poses risks to soil structure and long-term sustainability. These findings emphasize the need for careful management of diaper waste in agricultural settings to avoid negative impacts on soil health and food security. Further research is recommended to explore the ecological implications of diaper waste on agriculture, particularly in regions similar to Obubra L.G.A., where sustainable practices are vital for local economic stability. Implementing improved waste management strategies is essential to safeguard agricultural productivity and environmental health.

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Table 1. Soil Particle size as affected by different levels of diapers absorbents

Treatment	Sand (%)	Silt (%)	Clay (%)
Absorbent 0g	74.10ab	17.90b	8.00a
Absorbent 40g	71.60b	21.40ab	7.00a
Absorbent 80g	74.60a	19.40ab	6.00a
Absorbent 120g	72.10ab	23.40a	4.50a
Absorbent 160g	72.60ab	22.90ab	4.50a
Absorbent 200g	72.60ab	22.40ab	5.00a
Pre-Planting	74.60a	21.40ab	4.00a
LSD	**2.68**	**5.13**	**4.64**

Means with the same letter in a column for each factor are not significantly different ($P \leq 0.05$)

Table 2. Soil basic plant nutrients as affected by different levels of diapers absorbents

Treatment	pH (H2O)	N (%)	P (Mg/kg)	K (cmolkg-1)	OC (%)	OM (%)
Absorbent 0g	6.26d	0.16b	12.55a	0.13f	1.78a	3.07a
Absorbent 40g	6.48c	0.13de	9.50c	0.16d	1.42cd	2.46cd
Absorbent 80g	6.65b	0.16bc	9.75c	0.20a	1.58b	2.71b
Absorbent 120g	6.64bc	0.12e	9.40c	0.19b	1.42cd	2.46cd
Absorbent 160g	6.88a	0.14cd	7.90d	0.14e	1.38d	2.39d

Absorbent 200g	6.76ab	0.16bc	7.10e	0.14e	1.48c	2.56c
Pre-Planting	6.65b	0.20a	10.40b	0.17c	1.85a	3.18a
LSD	**0.17**	**0.02**	**0.45**	**0.004**	**0.08**	**0.13**

Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05)

Table 3. Effects of different levels of diapers absorbents on soil exchangeable plant nutrients.

Treatment	EA (cmolkg-1)	ECEC (cmolkg-1)	Ca (cmolkg-1)	Mg (cmolkg-1)	BS (%)
Absorbent 0g	0.66b	9.64b	5.80ab	3.00ab	93.16bc
Absorbent 40g	0.48c	9.50c	5.40b	3.40a	94.95a
Absorbent 80g	0.76a	9.83a	6.20a	2.60bc	92.24c
Absorbent 120g	0.60b	9.25d	5.40b	3.00ab	93.49b
Absorbent 160g	0.46c	7.83f	4.60c	2.60ab	94.08b
Absorbent 200g	0.80a	8.57e	5.40b	2.20c	90.68d
Pre-Planting	0.60b	9.65b	6.20a	2.60bc	93.78b
LSD	**0.09**	**0.10**	**0.67**	**0.67**	**0.94**

Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05)

Table 4 Maize dry matter weight in grams as affected by different levels of diapers absorbents.

Treatment	Maize Dry Matter Weight (g)
Zero Absorbent	9.73a
40g/10kg soil	4.54b
80g/10kg soil	1.47c
120g/10kg soil	0.51c
160g/10kg soil	0.28c
200g/10kg soil	0.22c
SE	**0.92**

Means with the same letter in a column for each factor are not significantly different (P ≤ 0.05)
SE = Standard Error