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Impact of Agricultural Fertilizers on Groundwater Quality in the Bani Walid Area - Libya

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ABSTRACT

The research presented in this review reveals that fertilizers, in addition to strengthening the agriculture sector, pollute soils and ground water. The essential elements found in fertilizers are necessary for improving soil quality and promoting healthy agricultural plant growth. Fertilizers are very important for agriculture, but they are also bad for the environment, people, and animals. They contain a variety of pollutants, such as radionuclides and heavy metals, in addition to mineral nutrients. In addition to inorganic fertilizers, organic fertilizers introduce organic contaminants, diseases, and potentially hazardous and toxic metals into soils and waterways. However, because they improve soil microbial variety, aeration, moisture content, nutrient status, and organic matter, organic fertilizers are better for soil health. Proper processing of organic fertilizers is necessary to remove unwanted metals, organic compounds, and pathogens before application to soil.

Keywords- Agricultural, Groundwater Quality, Fertilizers, environment and diseases.

I. INTRODUCTION

Agricultural fertilizers are considered essential elements in the agricultural sector, as farmers rely on them to enhance crop growth and increase land productivity(1). Fertilizers are used to compensate for deficiencies in nutrients that plants need, such as nitrogen, phosphorus, and potassium, which are crucial for stimulating photosynthesis and promoting root and stem growth, ultimately leading to increased agricultural productivity and quality(2). Although fertilizers contribute to improving food production and meeting the increasing demands of the population, the growing and intensive reliance on chemical fertilizers, especially nitrogenous and phosphorus types, has led to numerous negative side effects on the environment and human health(3).

One of the most prominent challenges posed by chemical fertilizers is their negative impact on groundwater quality, as using large quantities of these fertilizers can lead to the leaching of chemical compounds into lower soil layers and subsequently into groundwater(4). It is well known that nitrates and phosphates, which are primary components of fertilizers, have a high solubility in water, facilitating their transport with irrigation water or rainfall towards deep soil layers, reaching groundwater reservoirs(5). This leaching poses a threat to groundwater quality, which residents of agricultural areas in Bani Walid rely on for both agricultural use and as a source of drinking water(6).

The Bani Walid area heavily depends on groundwater to meet its water needs, given the scarcity of surface water resources in the region (7). This significant reliance on groundwater, along with the intensive use of chemical fertilizers in agriculture, makes studying the impact of fertilizers on groundwater quality a matter of utmost importance(8). This impact is compounded in agricultural areas with high soil permeability, which accelerates the leaching of chemical substances into groundwater, increasing the likelihood of contamination and amplifying the risks of negative effects on human health and the surrounding environment(9).

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Previous studies have shown that unplanned use of nitrogenous and phosphorus fertilizers can lead to high concentrations of nitrates and phosphates in groundwater, which may be associated with adverse health effects on humans, such as respiratory problems and increased risk of diseases such as stomach cancer and "blue baby syndrome" in children exposed to water with high nitrate levels. Additionally, phosphate contamination can lead to the formation of harmful algae in surface water bodies when these contaminated waters reach rivers or lakes, contributing to increased environmental pollution problems(10).

Accordingly, this research aims to study the impact of using agricultural fertilizers on groundwater quality in the Bani Walid area by analyzing the results of previous studies that have addressed this issue in similar environments and clarifying the severity of chemical contamination resulting from fertilizer leaching into groundwater, as well as identifying the key environmental and soil factors that contribute to increasing or decreasing the impact of this pollution. This research emphasizes the importance of raising awareness among farmers about the studied and sustainable use of fertilizers and directing efforts toward finding agricultural alternatives that help mitigate negative environmental impacts on groundwater, contributing to the preservation of water resources for future generations.

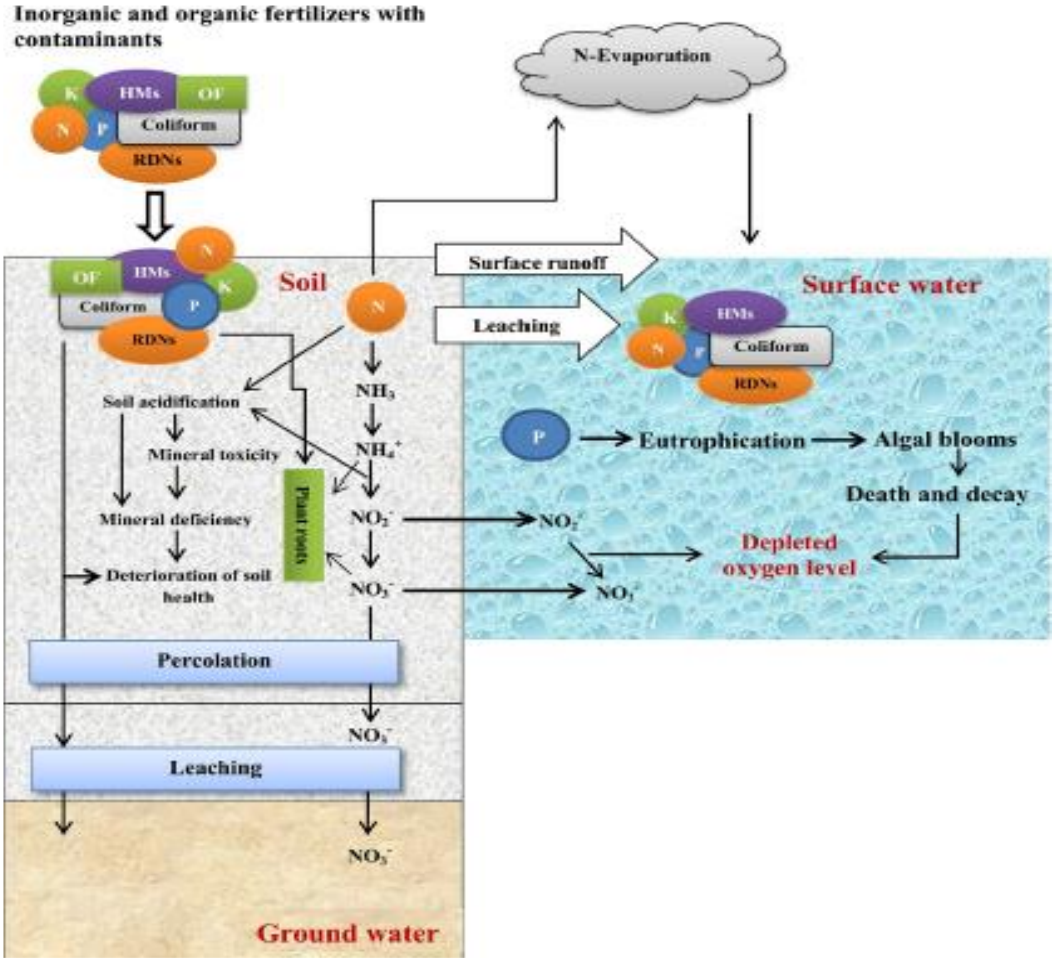

Fig. 1 Impact of inorganic and organic fertilizers and their contaminants in soil, surface and groundwater.

Application of inorganic fertilizers to the soil, along with mineral nutrients, adds HMs, RDNs, organic pollutants and pathogens to the soil. Nitrogen from applied fertilizers gets converted to NH_3 and NH_4þ that oxidizes to NO_3 and produces protons (Hþ) and decreases soil pH that results in the acidification of soil(11). Acidified soil causes mineral toxicity and mineral deficiency that ultimately results in the soil with poor health. NO_3 from the soil contaminates surface water and groundwater resources. Moreover, NO_2 also enters surface water and gets oxidized to NO_3 by dissolved oxygen in water which causes depletion of oxygen level in water. Phosphorous from the soil leaches to surface water bodies and causes eutrophication that results in algal blooms which on death and decay deplete the dissolved oxygen level. HMs, RDNs, and coliforms enter the food chain from soil through plants and water resources and adversely affect the ecosystem, and human and animal lives. HMs, heavy metals; RDNs, radionuclides; OF, organic fertilizers; NO_3, nitrate; NO_2, nitrite; NH_3, ammonia; NH4þ, ammonium.

Fertilizers and Water Quality:

One of the most significant environmental issues facing the world today is the degradation of water quality(12). Livestock and agriculture are thought to be the main nonpoint sources of water contamination(13). The main sources of agricultural nutrients include aquaculture, concentrated livestock dung, fertilizer leaching, and runoff from agricultural areas(14).

Inorganic Fertilizers and Water Quality:

Since the early 1960s, the global application of nitrogen and phosphorus fertilizer in agriculture has increased eightfold and thrice. Rainwater, erosion, irrigation canals, and seepage all carry nutrients from fertilizers into neighboring streams and lakes(15). Additionally, these nutrients negatively impact the physicochemical characteristics of water and contaminate subterranean water supplies through leaching(16). Water bodies that are enriched with nutrients develop a condition called eutrophication, which encourages the growth of unwanted aquatic plants and cyanobacteria (blue-green algae) surface blooms. The organic matter from unwanted aquatic plants decomposes, lowering the oxygen content of the water body and limiting its usage for drinking, industry, recreation, and fishing. revealed that HMs were present in commercial fertilizers as contaminants for the first time(17).

Organic Fertilizers and Water Quality:

Organic fertilizers meet the nutrient needs of crops and are widely utilized as soil amendments(18). Organic fertilizers not only supply nutrients but also keep the soil moist, aerated, and conducive to the growth of soil microorganisms. However, organic manure contains nutrients, HMs, and fecal coliforms that enter water bodies, deteriorate water quality, and pose major risks to public health and the environment(22). The majority of organic farming systems employ manures or compost as a source of nitrogen, and the rates at which manure is applied depend on the crop's nitrogen needs(23). Therefore, excess P will typically develop on fields after years of applying compost or manure.

Importance of the Research:

1. Protecting Water Resources: The research helps raise community awareness about the importance of preserving groundwater quality, which is a vital source of water in the Bani Walid area.
2. Improving Public Health: By understanding the impact of chemical fertilizers on groundwater, risks associated with water contamination, such as nitrate poisoning and respiratory diseases, can be reduced.
3. Promoting Sustainable Agriculture: The research guides agricultural practices toward responsible and sustainable fertilizer use, helping to protect the environment.
4. Providing Scientific Data: The research offers information supported by data from previous studies, contributing to enhancing knowledge about the impact of fertilizers on the environment.
5. Supporting Agricultural Policies: The research provides recommendations that can help governmental entities formulate agricultural policies that support sustainability and improve fertilizer management.
6. Stimulating Agricultural Innovation: The research encourages the adoption of new agricultural technologies and alternatives to chemical fertilizers, such as organic fertilizers, to enhance crop productivity without harming water quality.
7. Raising Awareness: The research aims to elevate awareness among farmers and the local community about the importance of the studied use of fertilizers and their impact on the environment.

Research Objectives:

This research aims to achieve several main objectives, including:

1. Assessing the Impact of Nitrogenous and Phosphorus Fertilizers on Groundwater Quality: The research seeks to study the extent of fertilizer use's impact on pollution levels in groundwater in the Bani Walid area and identify toxic concentrations that may affect public health and the environment.
2. Analyzing Environmental and Soil Factors: The research aims to identify the factors contributing to the leaching of chemical compounds into groundwater, such as soil type, depth of groundwater, and irrigation methods used. By understanding these factors, effective strategies for pollution reduction can be developed.
3. Providing Recommendations for Sustainable Fertilizer Management: The research seeks to propose sustainable agricultural practices that reduce the negative impact of fertilizer use on water quality, including directing the use of organic fertilizers and modern agricultural techniques that enhance resource efficiency.
4. Stimulating Awareness and Education Among Farmers: The research aims to enhance awareness among farmers about the impact of fertilizers on groundwater, which may lead to more sustainable agricultural decisions. Through this awareness, the use of harmful fertilizers can be reduced, and overall water quality can be improved.
5. Expanding the Scope for Future Studies: The research seeks to open new avenues for scientific research in this field, contributing to enhancing knowledge about the impact of agricultural fertilizers on groundwater and encouraging researchers to conduct future studies addressing similar issues in other areas.

Research Problem:

The main problem addressed in this research is the impact of agricultural fertilizer use on groundwater quality in the Bani Walid area. The increasing use of chemical fertilizers in agriculture is one of the primary factors contributing to groundwater pollution, posing a threat to the health of the population and the environment. Consequently, three sub-problems related to this main issue can be identified:

1. Nitrate and Phosphate Leaching into Groundwater: The intensive use of nitrogenous and phosphorus fertilizers is associated with increased nitrate and phosphate levels in groundwater, leading to pollution. This pollution poses a significant threat to the environment and negatively impacts the quality of water used for drinking and agriculture, potentially leading to various health problems.
2. Health Effects on the Community: Contamination of groundwater with fertilizer compounds can result in serious health effects for residents who rely on this water. These effects include health issues such as nitrate poisoning, which can lead to conditions like "blue baby syndrome" and other diseases related to the digestive and respiratory systems.
3. Lack of Awareness and Unsustainable Agricultural Practices: There is a lack of awareness among farmers about the dangers of chemical fertilizer use and its impact on water quality. Many farmers rely on traditional agricultural techniques that may exacerbate the water pollution problem, necessitating increased awareness and education about sustainable agricultural practices.

II. PREVIOUS STUDIES

1. Study by Mohamed Ali (2020): In this study, the researcher analyzed the impact of nitrogenous fertilizers on groundwater quality in several agricultural areas in Libya. The researcher used statistical models to measure nitrate levels in groundwater and found a positive relationship between increased fertilizer amounts and elevated nitrate levels in groundwater. Results showed that some samples exceeded the limits set by the World Health Organization, indicating a significant public health risk. Based on these results, the researcher proposed the necessity of developing strategies for managing fertilizer use, such as improving sustainable agricultural techniques and raising awareness among farmers about the risks associated with nitrogenous fertilizers.
2. Study by Ahmed Salem and Khaled Ibrahim (2018): This study reviewed the environmental impacts of phosphorus fertilizers on soil and groundwater in agricultural lands. Through sampling soil and water, the study found that excessive use of phosphorus fertilizers leads to a significant increase in phosphate concentrations in groundwater, causing pollution that negatively affects biodiversity in the region. The study also noted that high phosphate concentrations lead to increased algal growth in nearby water bodies, impairing water quality. The study recommended the necessity of using natural fertilizer alternatives and sustainable agricultural techniques to mitigate pollution.
3. Study by Aisha Hassan (2019): This study conducted a comprehensive analysis of the leaching of agricultural chemicals, including fertilizers, into groundwater in several rural areas. The researcher used multiple data collection methods, including field surveys and water sample analysis. The study found that chemical leaching heavily depends on soil type, with sandy soils contributing to greater leaching of chemical compounds. The study recommends the need for regular monitoring of groundwater quality and raising awareness among farmers about techniques that reduce chemical leaching.
4. Study by Youssef Omar (2021): This study addressed the impact of agricultural activities, including fertilizer use, on groundwater quality in rural areas. Using data from various sources, the study showed that increased use of chemical fertilizers leads to a noticeable increase in pollutant levels in groundwater, contributing to the spread of water-related diseases. The study recommended enhancing awareness programs among farmers regarding sustainable agricultural practices and implementing stricter government policies on chemical fertilizer use.
5. Study by Sumaya Al-Hadi (2022): In this study, the researcher investigated the impact of agricultural fertilizers on groundwater quality in an agricultural area similar to Bani Walid. The researcher employed chemical analysis tools to determine nitrate and phosphate concentrations in water. The results indicated that unplanned use of chemical fertilizers increases nitrate concentrations in groundwater. The study proposed the development of educational programs for farmers to promote proper fertilizer use and minimize negative impacts on groundwater quality.
6. Study by Hala Al-Khateeb (2023): This study focused on analyzing the relationship between agricultural fertilizer use and groundwater pollution in various agricultural environments. The researcher conducted a field study to collect data on pollutant levels in water and found that high concentrations of nitrates and phosphates in groundwater are closely linked to traditional farming practices. The study also recommended encouraging the use of organic fertilizers and sustainable agricultural techniques, such as contract farming and crop rotation.

III. METHODOLOGY

This research relies on a comprehensive qualitative analysis of previous studies related to the impact of agricultural fertilizers on groundwater quality, with a focus on studies addressing agricultural environments similar to the Bani Walid area. This methodology aims to provide an accurate and detailed assessment of how fertilizer use practices affect groundwater, and the implications for human health and the environment.

Classification

Fertilizers are classified in several ways. They are classified according to whether they provide a single nutrient (e.g., K, P, or N), in which case they are classified as "straight fertilizers". "Multinutrient fertilizers" (or "complex fertilizers") provide two or more nutrients, for example, N and P. Fertilizers are also sometimes classified as inorganic (the

topic of most of this article) versus organic. Inorganic fertilizers exclude carbon-containing materials except ureas. Organic fertilizers are usually (recycled) plant- or animal-derived matter. Inorganic are sometimes called synthetic fertilizers since various chemical treatments are required for their manufacture. (24)

Single nutrient ("straight") fertilizers

The main nitrogen-based straight fertilizer is ammonia (NH_3) ammonium (NH_4^+) or its solutions, including:

- Ammonium nitrate (NH_4NO_3) with 34-35% nitrogen is also widely used.
- Urea ($CO(NH_2)_2$), with 45-46% nitrogen, another popular source of nitrogen, having the advantage that it is solid and non-explosive, unlike ammonia and ammonium nitrate.
- Calcium ammonium nitrate Is a blend of 20-30% limestone $CaCO_3$ or dolomite $(Ca,Mg)CO_3$ and 70-80% ammonium nitrate with 24-28 % nitrogen.
- Calcium nitrate with 15,5% nitrogen and 19% calcium, reportedly holding a small share of the nitrogen fertilizer market (4% in 2007).[28]

The main straight phosphate fertilizers are the superphosphates:

- "Single superphosphate" (SSP) consisting of 14–18% P_2O_5, again in the form of $Ca(H_2PO_4)_2$, but also phosphogypsum ($CaSO_4 \cdot 2\ H_2O$).
- Triple superphosphate (TSP) typically consists of 44–48% of P_2O_5 and no gypsum.

A mixture of single superphosphate and triple superphosphate is called double superphosphate. More than 90% of a typical superphosphate fertilizer is water-soluble.

The main potassium-based straight fertilizer is muriate of potash (MOP, 95–99% KCl). It is typically available as 0-0-60 or 0-0-62 fertilizer.

Multinutrient fertilizers

These fertilizers are common. They consist of two or more nutrient components.

Binary (NP, NK, PK) fertilizers

Major two-component fertilizers provide both nitrogen and phosphorus to the plants. These are called NP fertilizers. The main NP fertilizers are

- monoammonium phosphate (MAP) $NH_4H_2PO_4$. With 11% nitrogen and 48% P_2O_5.
- diammonium phosphate (DAP). $(NH_4)_2HPO_4$. With 18% nitrogen and 46% P_2O_5

About 85% of MAP and DAP fertilizers are soluble in water.

NPK fertilizers

NPK fertilizers are three-component fertilizers providing nitrogen, phosphorus, and potassium. There exist two types of NPK fertilizers: compound and blends. Compound NPK fertilizers contain chemically bound ingredients, while blended NPK fertilizers are physical mixtures of single nutrient components.

NPK rating is a rating system describing the amount of nitrogen, phosphorus, and potassium in a fertilizer. NPK ratings consist of three numbers separated by dashes (e.g., 10-10-10 or 16-4-8) describing the chemical content of fertilizers.[29][30] The first number represents the percentage of nitrogen in the product; the second number, P_2O_5; the third, K_2O. Fertilizers do not actually contain P_2O_5 or K_2O, but the system is a conventional shorthand for the amount of the phosphorus (P) or potassium (K) in a fertilizer. A 50-pound (23 kg) bag of fertilizer labeled 16-4-8 contains 8 lb (3.6 kg) of nitrogen (16% of the 50 pounds), an amount of phosphorus equivalent to that in 2 pounds of P_2O_5 (4% of 50 pounds), and 4 pounds of K_2O (8% of 50 pounds). Most fertilizers are labeled according to this N-P-K convention, although Australian convention, following an N-P-K-S system, adds a fourth number for sulfur, and uses elemental values for all values including P and K.[31]

Micronutrients

Micronutrients are consumed in smaller quantities and are present in plant tissue on the order of parts-per-million (ppm), ranging from 0.15 to 400 ppm or less than 0.04% dry matter. These elements are often required for enzymes essential to the plant's metabolism. Because these elements enable catalysts (enzymes), their impact far exceeds their weight%age. Typical micronutrients are boron, zinc, molybdenum, iron, and manganese.[24] These elements are provided as water-soluble salts. Iron presents special problems because it converts to insoluble (bio-unavailable) compounds at moderate soil pH and phosphate concentrations. For this reason, iron is often administered as a chelate complex, e.g., the EDTA or EDDHA derivatives. The micronutrient needs depend on the plant and the environment. For example, sugar beets appear to require boron, and legumes require cobalt,[1] while environmental conditions such as heat or drought make boron less available for plants

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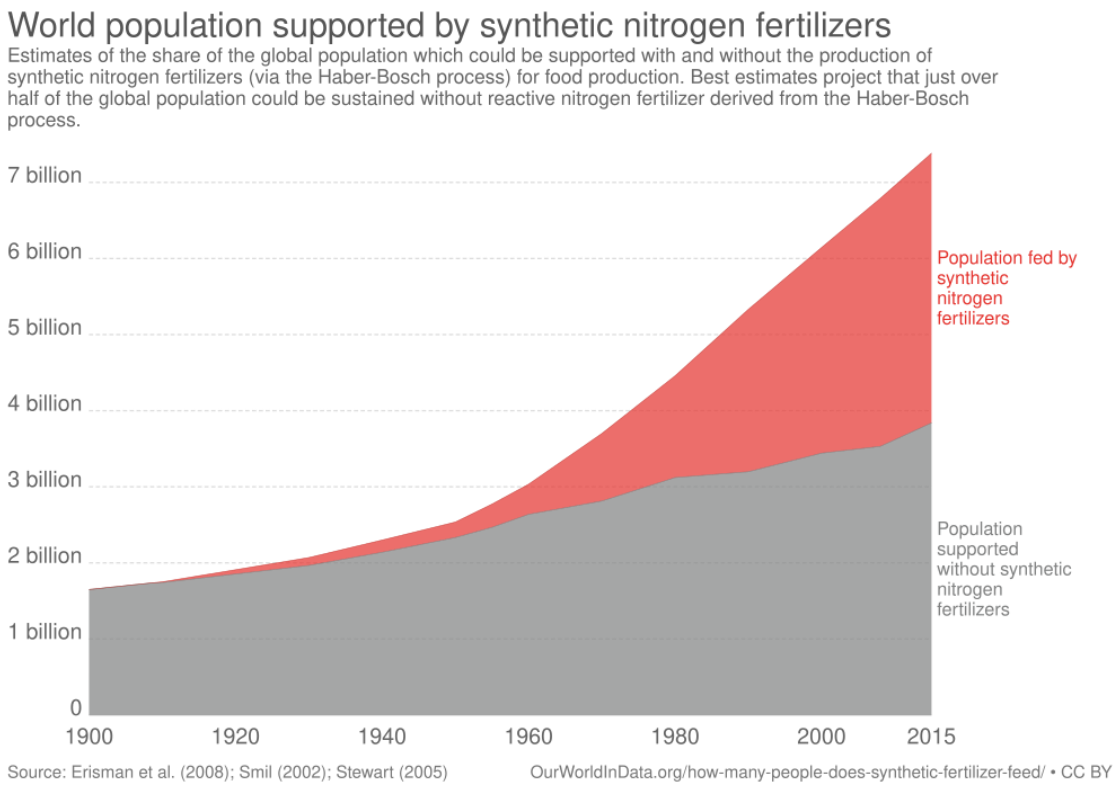

source: **"Total fertilizer production by nutrient". Our World in Data. Retrieved 7 March 2020.**

Potassium fertilizers

Potash is a mixture of potassium minerals used to make potassium (chemical symbol: K) fertilizers. Potash is soluble in water, so the main effort in producing this nutrient from the ore involves some purification steps, e.g., to remove sodium chloride (NaCl) (common salt). Sometimes potash is referred to as K_2O, as a matter of convenience to those describing the potassium content. In fact, potash fertilizers are usually potassium chloride, potassium sulfate, potassium carbonate, or potassium nitrate.

NPK fertilizers

Main article: NPK fertilizer

There are three major routes for manufacturing NPK fertilizers (named for their main ingredients: nitrogen (N), phosphorus (P), and potassium (K)):

1. bulk blending. The individual fertilizers are combined in the desired nutrient ratio.

Bulk blending. Ingredient kg/ton

Blend ingredient	NPK 17-17-17	NPK 19-19-19	NPK 9-23-30	NPK 8-32-16
ammonium nitrate	310	-	-	-
urea		256	-	-
diammonium phosphate (DAP)	376	421	500	462
triple superphosphate		-		261
potassium chloride	288	323	500	277
filler	26	-	-	-

1. The wet process is based on chemical reactions between liquid raw materials phosphoric acid, sulfuric acid, ammonia) and solid raw materials (such as potassium chloride).

- The Nitrophosphate Process. Step 1. Nitrophosphates are made by acidiculating phosphate rock with nitric acid.
- Nitric acid + Phosphate rock → Phosphoric acid + Calcium sulphate + hexafluorosilicic acid.
- $Ca_5F(PO_4)_3 + 10\ HNO_3 \rightarrow 6\ H_3PO_4 + 5\ Ca(NO_3)_2 + HF$
- $6\ HF + SiO_2 \rightarrow H_2SiF_6 + 2\ H_2O$

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Step 2. Removal of Calcium Nitrate. It is important to remove the calcium nitrate because calcium nitrate is extremely hygroscopic.

- Method 1.(Odda process) Calcium nitrate crystals are removed by centrifugation.
- Method 2. Sulfonitric Process $Ca(NO_3)_2 + H_2SO_4 + 2NH_3 \rightarrow CaSO_4 + 2NH_4NO_3$
- Method 3.Phosphonitric Process $Ca(NO_3)_2 + H_3PO_4 + 2NH_3 \rightarrow CaHPO_4 + 2NH_4NO_3$
- Method 4.Carbonitric Process $Ca(NO_3)_2 + CO_2 + H_2O + 2NH_3 \rightarrow CaCO_3 + 2NH_4NO_3$

Data Collection:

Data was collected from a wide range of scientific research addressing the impact of fertilizers on groundwater quality in agricultural areas with climatic and soil characteristics similar to those in Bani Walid. The following methods were used for data collection:

- Literature Review: Existing literature focusing on the subject was reviewed, including scientific articles, government studies, and academic theses. These sources were selected based on the quality of the research and their reliability, with a focus on studies published in recognized scientific journals. Among the reviewed studies were:

1. Hala Al-Khatib (2023): Explored the relationship between agricultural fertilizer use and groundwater contamination, showing that increased use of nitrogen fertilizers leads to higher nitrate levels in groundwater.
2. Aisha Hassan (2019): Provided an analytical study on the leakage of agricultural chemicals into groundwater, noting the impact of phosphate fertilizers on water pollution.
3. Ahmad Salem and Khaled Ibrahim (2018): Investigated the environmental impacts of phosphate fertilizers, confirming the close relationship between excessive fertilizer use and increased pollutant levels in water.
4. Mohamed Ali (2020): Focused on the impact of nitrogen fertilizers on groundwater contamination, highlighting potential health risks.
5. Somaya Al-Hadi (2022): Addressed the impact of agricultural fertilizers on groundwater quality, emphasizing the importance of awareness regarding the negative effects of unconsidered use.
6. Youssef Omar (2021): Reviewed the impact of agricultural activities on groundwater quality, noting the importance of adopting sustainable agricultural practices.

Criteria for Selecting Studies:

To verify the quality and relevance of the collected studies, a set of key criteria was followed:

- **Environmental Similarity:** Focus was placed on studies conducted in agricultural areas with similar climatic and soil environments to those in Bani Walid. For instance, studies addressing fertilizer impacts in regions with desert or semi-desert climates were selected, where agricultural patterns and excessive fertilizer use are similar.
- **Type of Fertilizers Used:** The study focused on nitrogen and phosphate fertilizers, which are heavily used in local agriculture. Studies including data on the quantities of these fertilizers used and evaluating their potential impacts on groundwater quality were chosen.
- **Pollution Results**: Studies providing clear and accurate data on the effects of fertilizers on groundwater quality were selected. Preference was given to studies containing chemical analyses of water, showing nitrate, phosphate, and other relevant pollutant levels. This element is essential for understanding the negative impacts associated with excessive fertilizer use in agriculture.

Qualitative Analysis:

After data collection, the results were analyzed qualitatively, where key patterns and common trends among the studies were extracted. This includes identifying environmental factors contributing to groundwater contamination due to fertilizers, as well as analyzing the health and environmental impacts resulting from this pollution. These results are documented within a conceptual framework that helps provide evidence-based recommendations for improving agricultural practices.

- Thematic Classification: The results extracted from the studies were classified based on key themes, such as pollution levels, health impacts, and effectiveness of alternative agricultural methods. This classification facilitates understanding the interrelated factors and their effects.
- Risk Assessment: A comprehensive assessment of the risks associated with fertilizer leakage into groundwater was conducted, including an analysis of potential health risks to local populations. Approved risk assessment tools were used to estimate the negative impacts of water pollution(20).

Identifying Research Gaps:

In addition to analyzing available data, this research seeks to identify gaps in current research on the impact of fertilizers on groundwater quality. The identified gaps include:

- Lack of Data on Specific Areas: Despite multiple studies on fertilizer impacts, there is a lack of data concerning the Bani Walid area, highlighting the need for local studies.
- Alternative Agricultural Practices: More research is needed on the effectiveness of sustainable alternatives to chemical fertilizers, such as organic fertilizers and their effects on water quality.
- Community Awareness: Current studies indicate a lack of awareness among farmers regarding the risks associated with fertilizers, necessitating strategies for education and awareness.

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Statistical Analysis:

In addition to qualitative analysis, some simple statistical methods were employed to analyze the available data. This includes calculating means and standard deviations of nitrate and phosphate concentrations in different studies, contributing to a more accurate view of the general trends in groundwater pollution.

Techniques Used:

A variety of modern techniques were used for data collection and analysis, such as:

- Spectroscopic Analysis: To determine pollutant levels in water samples.
- Statistical Software: Such as SPSS or R for data analysis and extracting statistical results.

IV. RESULTS

A review of previous studies clearly indicated that the intensive use of agricultural fertilizers, especially nitrogen and phosphate, leads to the leaching of nitrates and phosphates into groundwater. This effect has been documented in several scientific research, suggesting that these compounds can sometimes reach levels exceeding the safe limits recommended by health and environmental organizations.

For instance, Mohamed Ali's study (2020) showed that nitrate accumulation in groundwater leads to an increased risk of health disorders such as Methemoglobinemia, a condition that reduces the blood's ability to carry oxygen. Children and the elderly are considered the most vulnerable groups to this risk. In one of the studied areas, nitrate levels reached 45 mg/L, which is higher than the permissible limit of 10 mg/L set by the World Health Organization, raising concerns about the health of residents in that area.(19)

Moreover, the results of a study conducted by Ahmad Salem and Khaled Ibrahim (2018) indicated that sandy soil areas, such as those in Bani Walid, are more susceptible to the leaching of these compounds. Sandy soil has limited capacity to retain water and nutrients, facilitating the leaching of nitrates and phosphates into groundwater. Data shows that chemical pollution in groundwater in these areas is 30% higher compared to areas with clay soil. This increases the likelihood of health issues arising from the consumption of contaminated water, such as gastrointestinal diseases and respiratory problems.

V. CONCLUSIONS

Frequent, long-term fertilizer applications build up nutrients in the soil, which then drain and surface discharge into groundwater and surface water supplies, rendering the water unfit for human use. For example, eutrophication, which leads to algae blooms and deteriorated water quality, is caused by P from agricultural fields entering surface water bodies. Additionally, fertilizers introduce heavy metals (HMs) into the soil, which are absorbed by plants and move up the food chain to impact the lives of humans and animals. When nitrogen from nitrogenous fertilizers leaches into groundwater sources, it is transformed into NO_3, a potentially lethal pollutant. Therefore, crop varieties that make use of the available resources are needed to combat the negative impacts of fertilizers and their pollutants.

RECOMMENDATIONS

Based on the findings extracted from the research, the study offers a set of important recommendations:

1. Reduce Chemical Fertilizer Use: Farmers should be encouraged to decrease reliance on traditional chemical fertilizers and shift towards using organic fertilizers. Studies indicate that organic fertilizers do not lead to significant leaching of nitrates and phosphates into groundwater, thereby reducing pollution. Farmers can improve soil fertility by using natural manure and sustainable agricultural practices such as crop diversification and crop rotation.
2. Monitor Pollution Levels Periodically: It is essential to establish a system for periodically monitoring nitrate and phosphate levels in groundwater. Regular water testing in wells and other water sources is advised to ensure that pollution levels do not exceed safe limits. This monitoring should include regular analysis of various pollution factors to assess the effectiveness of measures taken to reduce pollution.
3. Raise Farmer Awareness: Awareness campaigns should be established for farmers about the potential risks resulting from irresponsible fertilizer use. Workshops and training sessions can be organized to inform them about the importance of applying sustainable agricultural practices, such as precision farming techniques and applying fertilizers based on soil analysis. Education can help enhance farmers' understanding of the relationship between fertilizer use and groundwater quality, leading to positive changes in their agricultural behavior.
4. Encourage Scientific Research: More research in this field should be supported, as there is an urgent need to more accurately determine the impacts of fertilizer use on groundwater. Future studies can contribute to developing new strategies to reduce chemical pollution levels and protect water resources.

5. Develop Government Policies: It is important for the government to adopt policies that encourage sustainable fertilizer use. These policies could include providing financial incentives for farmers using organic fertilizers, as well as tightening regulations on chemical fertilizer use, contributing to environmental protection and community health.
6. Explore Sustainable Alternatives: Research should be conducted to find and develop sustainable alternatives to chemical fertilizers, such as biological fertilizers and natural compounds that improve soil fertility without negatively affecting water quality.

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