The Effect of Fertilizer Use on Eutrophication

Environmental Systems and Societies

How does of different concentrations (75gm^{-2}, 85gm^{-2} ,95gm^{-2}, 105gm^{-2}, 115gm^{-2}) of agricultural use of chemical fertilizers with sulphur content (ammonium sulphate) [$(NH_4)_2SO_4$], with phosphor content (diammonium hydrogen phosphate) [$(NH_4)_2HPO_4$] and organic fertilizers (humic acid) effect-with traditional watering regime- the eutrophication level in freshwater ecosystems?

Word Count: 3989

ABSTRACT

People depend on agriculture to feed, with increasing world population the demand for freshly grown vegetables and fruits multiplies every year. To meet this demand, excess amounts of fertilizers are used to grow crops faster. But at what cost?

Using excessive fertilizers has a deadly effect on not only the soil but also on the marine ecosystem. Leakage water is used as a transfer mechanism to carry vast amounts of excess fertilizers to freshwater resources such as lakes and rivers.

Therefore, the objective of this study is to compare the test the impacts of using excess fertilizers to the marine ecosystem. Throughout this investigation one type of organic fertilizer: Humic Acid and two types of chemical fertilizers: Ammonium Sulphate $(NH_4)_2SO_4$ and Diammonium Hydrogen Phosphate $(NH_4)_2HPO_4$ will be tested using increased concentrations of ($75gm^{-2}$, $85gm^{-2}$,$95gm^{-2}$, $105gm^{-2}$, $115gm^{-2}$) each in different systems to see if they have an effect on eutrophication caused by the leakage of irrigation water.

Table of Contents

1.Introduction

1.1.The Agricultural Use of Fertilizers

Fertilizers are a necessity in the farming industry. Described by the International Fertilizer Association, a fertilizer is a mineral plant nutrient which is an element that is necessary or advantageous for plant growth and development, as well as the quality of the harvested product of a certain plant species produced in its natural or cultivated habitat.[1] Moreover, with advanced research from the University of Nebraska it was found that the earliest use of fertilizers dated back to 8000 years. That is roughly 5500 years before the wheel was invented in Mesopotamia.[2]

As populations grew following the industrial revolution, governments were challenged by how to feed their citizens. The solution came from a German scientist Fritz Haber in 1909.[3] Haber discovered that a chemical reaction between hydrogen and nitrogen produced ammonia, the main component of chemical fertilizers. At the time, the high demand for chemical fertilizers soon rose concerns about eutrophication and pollution.

The first time I found out that there were different types of fertilizers was when I watched the movie “Martian”. To briefly give a context, the movie is about a botanist astronaut who is forced to live on Mars until help reached him. Through his journey the protagonist faces food shortage. The part that caught my attention is when he used his faeces as a fertilizer to grow food. The question of “What are different kinds of fertilizers?” wondered in my head for several days. Finally, I asked a farmer friend of my father’s. The answer was simple yet so confusing, every part of an organism’s body is a fertilizer. As a result, I started doing research about fertilizers and their effects on environment.

Results of my research stated that there are two kinds of fertilizers, organic and chemical. While organic fertilizers are made up of different components of organisms: faeces, bones, skin etc. Chemical fertilizers are manufactured in laboratories by scientists. Furthermore, I gathered information that chemical fertilizers such as ammonium sulphate and diammonium hydrogen phosphate could cause damage to the environment such as pollution of waterways, agricultural chemical burn, increased air pollution, soil acidification, and mineral depletion. Meanwhile, there is little risk in using organic fertilizers as they are easily broken down by microorganisms in the soil.

1.2. About Humic Acid

Humic acid is an organic fertilizer which is composed of faeces of organisms, it is soluble in water with higher pH. It plays a crucial role in plant growth as it is a medium of transport for nutrients from the soil to the roots of the plants. Since its first use in Germany in 1786, articles upon the benefits of using humic acid were published. Scientific research has proven that, as it is a natural substance humic acid does not pose a threat to the environment.[5]

1.3 About Ammonium Sulphate ($(NH_4)_2SO_4$)

Ammonium sulphate ($(NH_4)_2SO_4$), is used commonly as a synthetic fertilizer for alkaline soils. When ammonium ion is introduced into damp soil, a sulphate ion is released. This produces a small amount of acid, which lowers the soil's pH balance. It also provides nitrogen, which aids plant growth. It dissolves slowly, making it less expensive than some other artificial fertilizers. Ammonium sulphate is also used as an herbicide because it burns the leaves of plants, killing them or weakening them for easy removal.[4] Farmers use Ammonium sulphate as an alternative to organic fertilizers for two reasons. It is affordable and effortless. However, ammonium sulphate is a hazardous matter. It reacts readily with water and has deadly consequences. When heavy amounts of Ammonium sulphate are integrated into damp soil. The unabsorbed substances get washed away by irrigation and bind into the nearest freshwater supply, meaning a river or a lake. Ammonium is easily converted into nitrate (NO^{3-}) in water ecosystems with enough dissolved oxygen or into nitrogen gas in water bodies with no dissolved oxygen. This results in shortages of oxygen for sea plants and fish living under water. Furthermore, the increased amount of sulphate ions (SO_4^{-2}) act as a nutrient for aquatic algae.[6] As algae population skyrocket with increasing nutrition, a thick layer of freely floating duckweed and algae form on the surface of the waterbody. The dark-coloured algae further cut the supply of sunlight and oxygen needed for the growth of aquatic plants and marine animals. The situation could be identified as positive feedback and result in eutrophication which takes great effort to refurbish.

1.4. About Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]

Diammonium hydrogen phosphate [$(NH_4)_2HPO_4$], just like ammonium sulphate is an inorganic fertilizer used in the farming industry, as it is highly soluble in water, to grow crops such as cotton, peanut, and vegetables. When the excess [$(NH_4)_2HPO_4$] which is not taken up by the roots of the plants reacts with water, it could cause eutrophication, because of increased levels of ammonium and phosphate ions, which can lead to multiplied algal growth. Lower dissolved oxygen concentrations in the water ecosystems resulting from algae decomposition pose as a tremendous danger to organisms living within.[8]

Diammonium hydrogen phosphate and ammonium sulphate have relatively close nitrogen contents with 18% and 21% respectively. However, diammonium hydrogen phosphate does not possess sulphur just as ammonium sulphate does not possess phosphor. Therefore, my objective will be to consider the effects of sulphur and phosphate ions on eutrophication when they are dissolved in water.

2. Methodology

2.1. Aim and Research Question

In this investigation my aim is to compare the negative effects of concentrations ($75gm^{-2}$, $85gm^{-2}$,$95gm^{-2}$, $105gm^{-2}$, $115gm^{-2}$) of chemical (Ammonium sulphate, Diammonium hydrogen phosphate) and organic fertilizers (humic acid) used in the farming industry on the eutrophication levels of freshwater ecosystems. I decide to conduct this experiment by modelling a simplified farmland. Therefore, upon this paper I will focus on the research question of:

"How does the concentration ($75gm^{-2}$, $85gm^{-2}$,$95gm^{-2}$, $105gm^{-2}$, $115gm^{-2}$) of agricultural use of chemical fertilizers with sulphur content (ammonium sulphate $(NH_4)_2SO_4$), with phosphor content (diammonium hydrogen phosphate) [$(NH_4)_2HPO_4$] and organic fertilizers (humic acid) with traditional watering regime on the eutrophication level in freshwater ecosystems?

The aim of this paper will be on evaluating the results of the experiment conducted and drawing a conclusion upon the validity of the evaluations.

2.2. Hypothesis

According to recent research, it is recorded that 80% of marine pollution is caused by nutrient pollutants. Nutrient pollutants refer to the contamination of nutrients such as, nitrates, sulphate and many more. Nutrient pollutants are said to be the primary reason behind eutrophication of water ecosystems.[7] Regardless of the type of fertilizer, the amount of fertilizer used for a meter square of farming land is increased by the same margin, so it is predicted that there will be increased amount of nutrients in the excess water flowing out of the system, resulting in higher possibility of eutrophication.

If a comparison should be made between chemical and organic fertilizers: on average 20% of chemical sulphate fertilizers are lost as groundwater or surface runoff, it is very likely that, the leaching of excess ammonium sulphate which has a chemical content of nitrogen and sulphate ions will cause more eutrophication in a water system with a traditional water regime when compared to leaching of humic acid which is an organic compound not containing hazardous elements. Likewise, the dissolved diammonium hydrogen phosphate will give out more ammonium and phosphate ions into the freshwater ecosystem compared to humic acid. As humic acid is composed of faeces of organisms it is recorded to have no negative effects on freshwater ecosystems.

As only 10- 30% of nutrients in phosphate fertilizers are absorbed by the crops, while 5-12% of nutrients in sulphate fertilizers are absorbed by crops, through recent research it could be argued that the eutrophication levels in an ecosystem with use of ammonium sulphate will be higher than ecosystems where Diammonium hydrogen phosphate is used as a fertilizer.

Considering previous research, it can be hypothesised that in the speculated farming ecosystem where the soil will be fertilized with ammonium sulphate and Diammonium hydrogen phosphate, the amount of excess nutrients measured in the runoff of leached water will be higher than the amount of nutrients found in leached water from the farming system where humic acid is used as a fertilizer. On the other hand, it is hypothesized that, in all types of fertilizers increasing the amount used will always increase the amount of excess nutrients in the runoff water. Also, it is also hypothesized that the amount of nitrogen ions in the runoff water of

Diammonium hydrogen phosphate will be lower than that of ammonium sulphate as ammonium sulphate has a higher nitrogen content.

2.3.Method Development and Planning

Designing an appropriate method to support or reject the proposed hypothesis and answer the given research question presented numerous challenges. The first one was to design the adequate experimentation system to conduct. After research I have found that, traditionally 75 grams of fertilizer is used for 1 square meter of land. As it was impossible to provide 1 meter square of land for each trial. I narrowed the volume of the system to 2.5 dm^3, using plastic flowerpots to but the soil in. Therefore, I ratioed the amount of fertilizer to 75 grams per square cube and found out that 330 milligrams of fertilizer (both organic and chemical) were the advised amount to use by legal authorities.

Another challenge was to decide on the range of the independent variable, and to measure a clear difference I set the range to 10 grams per square cube, which meant for every system that is 2.5 $dm^{3:}$ 330, 3370, 410, 450 and 490 milligrams of fertilizer will be put in, to measure the change in the amount of nutrients in the excess water without difficulty. This will be done for each type of fertilizer, meaning that there will be 15 trials, three kind of fertilizer and five concentrations for each kind.

Furthermore, as the aim of the investigation was to measure the amount of eutrophication causing nutrients in the water that is flowing through the system to water bodies, I came up with the idea of connecting pipes at the bottom of the plastic pots which will collect excess water into a separate cup, as well as the excess nutrients flowing through with water.

I then thought of using a special device, called a PORTABLE TOTAL NITROGEN/ PHOSPHORUS/SULPHUR METER MODEL TNP-10 DKK-TOA Meter, designed to detect the amount of dissolved nitrogen and phosphorus in the water to evaluate the effect of the fertilizer used to the amount of excess nutrients in water that ae used by microorganisms such as algae to lead to eutrophication and compared the values I obtained to the information on the previous eutrophication cases which were recorded by professional organizations.

Variables:

Independent Variable	The concentration of each fertilizer used in separate experiments 75gm^{-2}, 85gm^{-2} ,95gm^{-2}, 105gm^{-2}, 115gm^{-2}, and type of fertilizers (ammonium sulphate [$(NH_4)_2SO_4$], diammonium hydrogen phosphate [(NH4)2HPO4], humic acid) used in systems for each concentration.
Dependent Variable	The amount of excess nutrients in the leakage water from the system which will be measured using a PORTABLE TOTAL NITROGEN/ PHOSPHORUS/SULPHUR METER MODEL TNP-10 DKK-TOA (±0.01) .
Derived Variable	The correlation between the amount of excess nutrients found in the leakage water and their effect on eutrophication, which will be derived to using previous real life samples of eutrophication and the excess nutrient levels in my investigation and investigation done by researchers will be compared to deduce a conclusion.

Controlled	**Method of control**	**Possible effects of outcomes**
The type and number of seeds used	The seeds will be all bought from the same brand and will be selected as close as possible in size	Different number of crops growing inside of the soil could lead to different amount nutrients in the leakage water
Amount and consistency of irrigation	All 15 of the cases will be watered with the same amount of water at the same time of the day	Varying amount of water used could lead to a mismeasurement in the amount of nutrients washed away by the water
Amount and type of soil	The soil in each box will be provided from the same brand at the same time	Different types of soil could have diverse properties such as the amount of water absorbed etc.

The plastic flowerpots, pipes and the containers holding excess water	All the materials used in the experiment will be supplied from the same brand at the same time	This will prohibit measurements resulting from materials used.
Temperature	All trials will be conducted at the same time, in the same room	This will prohibit mismeasurements resulting from evaporation or condensation of water because of temperature
Altitude and pressure of the room	The experimentation will be conducted in the same room	Decrease outside effects which could lead to mismeasurements
Amount of solar radiation	The setup will be rotated every day for each box to get equal amount of solar radiation	Amount of solar radiation has a direct impact on the growth of the plant so influences the water absorbed by the roots
The number of trials for each concentration of fertilizer	Three trials will be conducted for every concentration of fertilizer type to maintain coherence between data and minimize error.	Increasing the number of trials will always result in an increase in precision and better data evaluation.

Risk Assessment:

Hazard	**Precaution**
Ethical	Plant seeds used in the experiment contain an embryo. Therefore, living organisms were used in the experiment. However, the seeds were specifically supplied for the investigation not changing the integrity of the ecosystem. The fertilizer level and type for the vegetation grown after the conduction of the experiment was stabilized by a Botanist to ensure the safety and health of the living organism, in this case being the plant grown out of the seed.
Environmental	The environmental concern of releasing the excess eutrophicated water into the nature was solved as the excess fluid was diluted with distilled water to a concentration not harmful to the environment.
Safety	There were chemicals used in the experiment. Therefore, during the plantation and cleaning process of the pots a laboratory coat, safety goggles, and latex gloves are required. As the fertilizers used were outsiders to the ecosystem, the soil used to grow crops were collected in a sealed bag and was disposed to a biohazard bin at the local landfill. Excess fertilizers were stored in a dry, sealed, dark bag to be disposed into a biohazard bin.

2.4.Method and Diagrams

Materials and Apparatus:

1. 3 × 2.5 dm^3 Flowerpots (±0.25 cm^3)
2. 25 dm^3 of Garden Soil (±0.01 dm^3)
3. 25 grams of Humic Acid (±0.01 g)
4. 25 grams of Diammonium hydrogen phosphate (±0.01 g)
5. 25 grams of Ammonium Sulphate (±0.01 g)
6. Thermometer (±0.05 °C)
7. Distilled Water
8. PORTABLE TOTAL NITROGEN/ PHOSPHORUS/SULPHUR METER MODEL TNP-10 DKK-TOA (±0.01) (Uncertainty calculated by the manufacturer)
9. Graduated cylinder (100 cm^3) (±0.1 cm^3)
10. 45 × jars (500 cm^3) (±0.1 cm^3)
11. 3 × plastic tubes
12. 100 grams of green onion seeds (±0.01 g)
13. Electronic scale (±0.01 g)

Procedure:

Outline:

First, there will be 15 independent case trials for this investigation. For each of the three types of fertilizers (two chemical, and one organic) five different concentrations will be tested and then compared.

To achieve an experimentation method as close to the actual environmental process, 3 plastic pots with 2.5 dm^3 in volume will be used, the pots will be cleaned after each trial to be used five times each due to cost reasons. In each pot, same amount of soil will be placed as well as same kind and number of plant seeds. The only difference in each trial will be the type of fertilizer and the amount.

The process will last approximately 15 days depending on the growth of the plant. Each day, the pots will be rotated for each box to get equal parts of solar radiation. The systems will be watered daily and equally throughout the process. The excess leaking water will be collected through a pipe connected at the bottom of the box into a glass jar.

At the end of the experimentation process, a special device belonging to the laboratories at local water and sewerage administration general directorate will be used to measure the amount of dissolved nitrogen, sulphur and phosphorus in the water collected inside all the jars. The findings will be compared to the values of nutrients in water found online of previous cases of eutrophication in the environment to clearly see if there is any the effect of type of fertilizer and the amount used to the freshwater ecosystems. The step for the procedure is as follows:

Steps of the Procedure:

For the first trial, clean the flowerpot that will be used. Connect the plastic tube that will be used to collect excess water to the bottom of the flowerpot through the already existing holes. Place a jar directly underneath the tube to collect excess water.

Pick, one of the three fertilizers, ammonium sulphate [$(NH_4)_2SO_4$], diammonium hydrogen phosphate [$(NH_4)_2HPO_4$] or organic fertilizers (humic acid). Then mix, the desired fertilizer with the garden soil for the first tested concentration of 70 gm^{-2}, to have a mixture of 2.5 dm^3.

Place the mixture of soil and fertilizer to the cleaned flowerpot, create a small cavity on the surface of the soil directly at the centre, place 2 grams of green onion seeds in the cavity, cover up the cavity.

Repeat this process for the other two types of fertilizers.

After all three systems are ready, water each pot with the same amount of distilled water with the same timeline for fifteen days. Rotate the flowerpots every day to sustain equal sunlight coverage for every pot.

After fifteen days, clean the flowerpots completely, to not waste the already grown vegetables, they were put in a controlled environment to be further grown to be consumed.

Store the jars that were used to collect excess water and label them with the concentration and the name of the fertilizer to avoid confusion.

Repeat this exact process for three trials to maximize precision and minimize the percentage of human error and other possible mistakes.

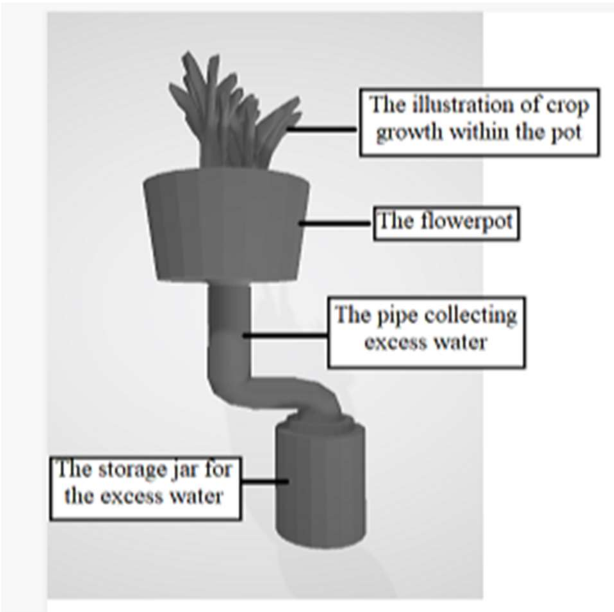
Repeat the same process for the different concentrations of the three fertilizers.

After 45 trials are done take the jars used to collect excess water to the local water and sewerage administration general directorate laboratories to measure and record the value of dissolved nitrogen and phosphorus in the water.

Measure and record the values of dissolve nitrogen, sulphur and phosphorus in the distilled water used to irrigate the flowerpots to have means for comparison.

Diagrams:

Illustration 1: The 3D Prepared Experimentation Method



2.5. Photograph:

The Materials Used in The Investigation

PORTABLE TOTAL NITROGEN/ PHOSPHORUS/SULPHUR METER MODEL TNP-10 DKK-TOA

3. Results

3.1. Raw Data Tables

Table 1: Raw Data Table Showing the Results of The Measured Dissolved Nitrogen Values

The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Measured Amount of Dissolved Nitrogen for Each Trial ($mgdm^{-3}$) (±0.01)**		
		Trial 1	**Trial 2**	**Trial 3**
Humic Acid	75.00	0.10	0.10	0.10
	85.00	0.12	0.12	0.12
	95.00	0.13	0.13	0.13
	105.00	0.15	0.15	0.15
	115.00	0.18	0.18	0.18
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	4.13	4.13	4.13
	85.00	5.22	5.21	5.23
	95.00	6.31	6.34	6.35
	105.00	7.39	7.38	7.41
	115.00	8.46	8.44	8.45
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	4.01	4.05	4.02
	85.00	5.09	5.11	5.07
	95.00	6.16	6.14	6.18
	105	7.25	7.22	7.21
	115.00	8.34	8.33	8.32

Table 2: Raw Data Table Showing the Results of The Measured Dissolved Phosphorus Values

The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Measured Amount of Dissolved Phosphorus for Each Trial ($mgdm^{-3}$) (±0.01)**		
		Trial 1	**Trial 2**	**Trial 3**
Humic Acid	75.00	0.01	0.01	0.01
	85.00	0.01	0.01	0.01
	95.00	0.01	0.01	0.01
	105.00	0.01	0.01	0.01
	115.00	0.01	0.01	0.01
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	0.00	0.00	0.00
	85.00	0.00	0.00	0.00
	95.00	0.00	0.00	0.00
	105.00	0.00	0.00	0.00
	115.00	0.00	0.00	0.00
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	6.53	6.51	6.54
	85.00	7.35	7.32	7.33
	95.00	8.17	8.15	8.13
	105.00	8.73	8.74	8.76
	115.00	9.45	9.42	9.41

Table 3: Raw Data Table Showing the Results of The Measured Dissolved Sulphur Values

The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Measured Amount of Dissolved Sulphur for Each Trial ($mgdm^{-3}$) (±0.01)**		
		Trial 1	**Trial 2**	**Trial 3**
Humic Acid	75.00	0.01	0.01	0.01
	85.00	0.01	0.01	0.01
	95.00	0.01	0.01	0.01
	105.00	0.01	0.01	0.01
	115.00	0.01	0.01	0.01
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	5.42	5.39	5.44
	85.00	5.53	5.51	5.49
	95.00	5.66	0.565	5.67
	105.00	5.72	0.570	5.74
	115.00	5.83	5.80	5.82
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	0.00	0.00	0.00
	85.00	0.00	0.00	0.00
	95.00	0.00	0.00	0.00
	105.00	0.00	0.00	0.00
	115.00	0.00	0.00	0.00

Table 4: Raw Data Table Showing the Results of The Measured Dissolved Nitrogen, Sulphur and Phosphorus Values in Distilled Water

The Measured Amount of Dissolved Nitrogen in Distilled Water ($mgdm^{-3}$) (±0.01)	**The Measured Amount of Dissolved Phosphorus in Distilled Water ($mgdm^{-3}$) (±0.01)**	**The Measured Amount of Dissolved Sulphur in Distilled Water ($mgdm^{-3}$) (±0.01)**
0.00	0.00	0.00

3.2. Data Processing

Sample Calculation for The Mean Amount of Dissolved Nutrients:

For the mean amount of dissolved nitrogen in 75 gm^{-2} of humic acid could be calculated by the equation:

$$\frac{The\ sum\ of\ dissolved\ nutrient\ measured\ in\ individual\ trials}{The\ number\ of\ trials} = The\ mean\ of\ dissolved\ nutrient$$

$$\frac{0.10 + 0.10 + 0.10}{3} = 0.10$$

Processed Data Table 1: The Means of Measured Amount of Dissolved Nitrogen in Each Concentration for Every Trial

The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Mean Amount of Dissolved Nitrogen for Each Concentration ($mgdm^{-3}$) (±0.01)**
Humic Acid	75.00	0.10
	85.00	0.12
	95.00	0.13
	105.00	0.15
	115.00	0.18
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	4.13
	85.00	5.22
	95.00	6.33
	105.00	7.39
	115.00	8.45
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	4.03
	85.00	5.09
	95.00	6.10
	105.00	7.23
	115.00	8.33

Processed Data Table 2: The Means of Measured Amount of Dissolved Phosphorus in Each Concentration for Every Trial

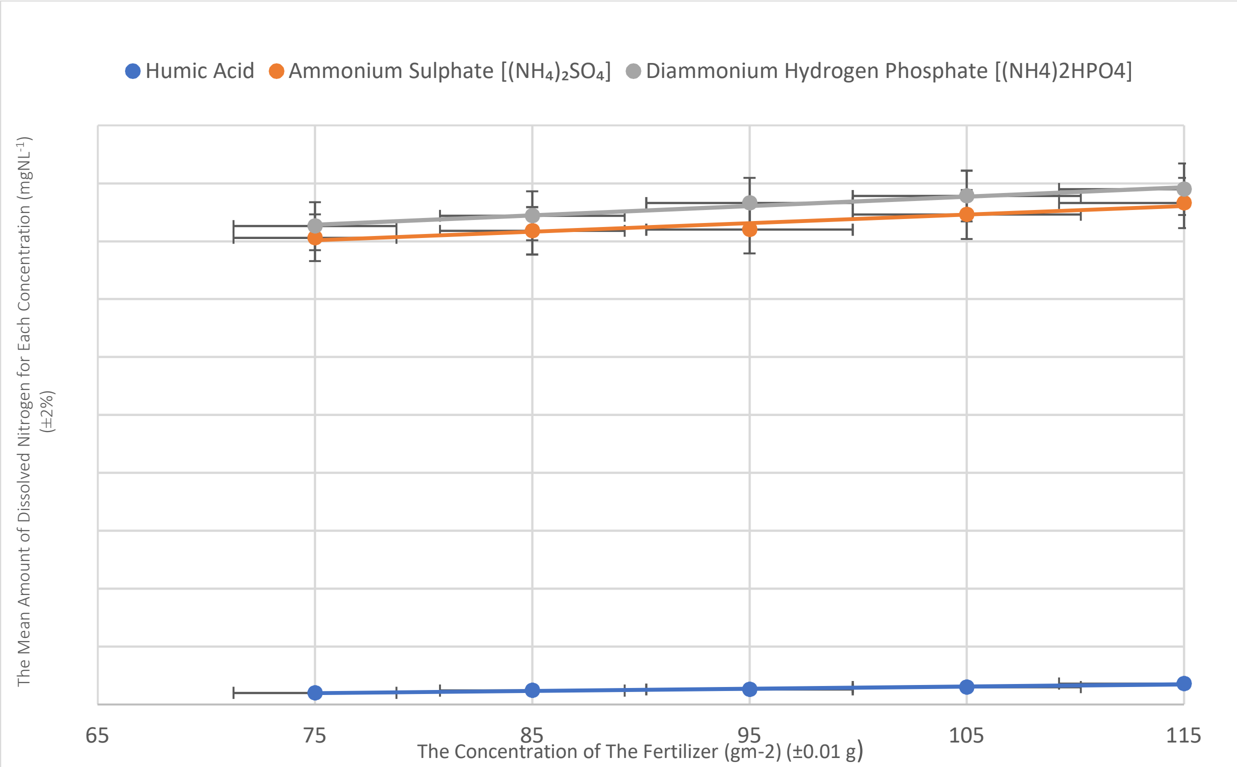
The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Mean Amount of Dissolved Phosphorus for Each Concentration ($mgdm^{-3}$) (±0.01)**
Humic Acid	75.00	0.01
	85.00	0.01
	95.00	0.01
	105.00	0.01
	115.00	0.01
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	0.00
	85.00	0.00
	95.00	0.00
	105.00	0.00
	115.00	0.00
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	6.53
	85.00	7.33
	95.00	8.16
	105.00	8.74
	115.00	9.43

Processed Data Table 3: The Means of Measured Amount of Dissolved Sulphur in Each Concentration for Every Trial

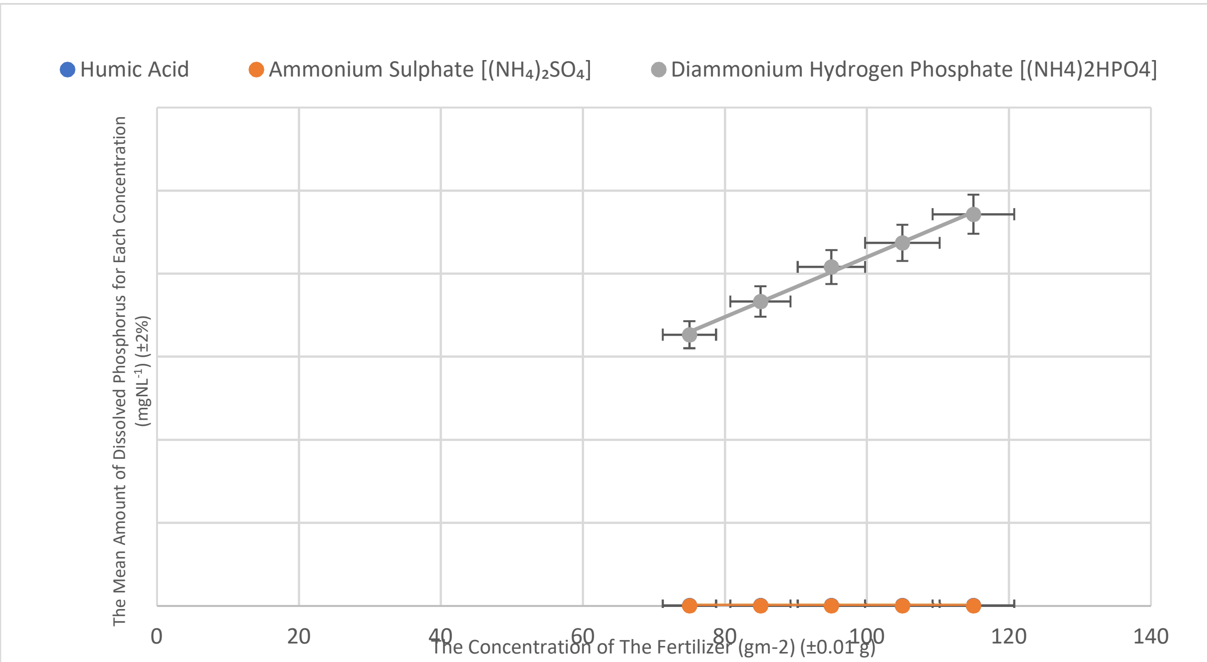
The Type of Fertilizer Used	**The Concentration of The Fertilizer (gm^{-2}) (±0.01 g)**	**The Mean Amount of Dissolved Sulphur for Each Concentration ($mgdm^{-3}$) (±0.01)**
Humic Acid	75.00	0.01
	85.00	0.01
	95.00	0.01
	105.00	0.01
	115.00	0.01
Ammonium Sulphate [$(NH_4)_2SO_4$]	75.00	5.41
	85.00	5.53
	95.00	5.66
	105.00	5.72
	115.00	5.82
Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]	75.00	0.00
	85.00	0.00
	95.00	0.00
	105.00	0.00
	115.00	0.00

3.3.Graphs:

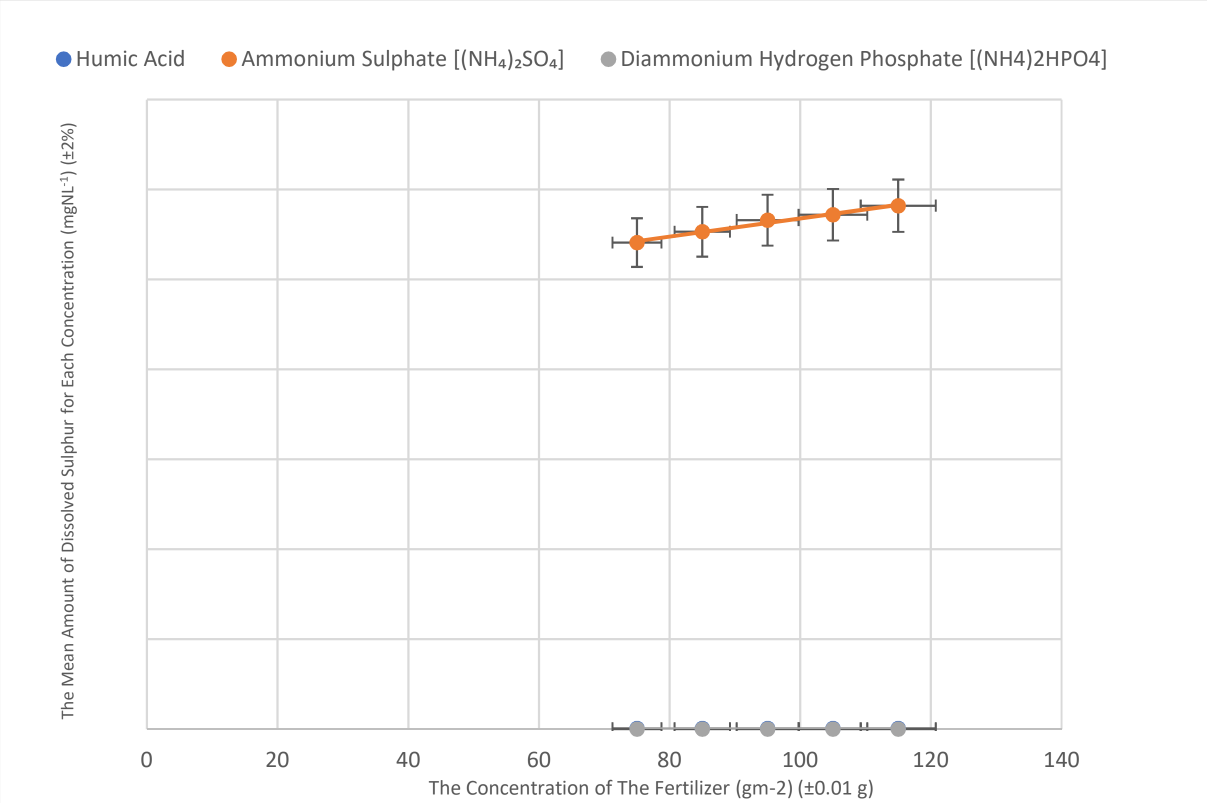
Graph 1: The Illustration of The Concentration of The Fertilizer for All Three Types of Fertilizer to the Amount of Dissolved Nitrogen in Excess Water



Graph 2: The Illustration of The Concentration of The Fertilizer for All Three Types of Fertilizer to the Amount of Dissolved Phosphorus in Excess Water



Graph 3: The Illustration of The Concentration of The Fertilizer for All Three Types of Fertilizer to the Amount of Dissolved Sulphur in Excess Water



3.4.ANOVA (Analysis of Variance)

ANOVA for each of the measured dissolved nutrients in the leakage water.:

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	123.8442	61.9221	31.9879	0.00001553
Error (within groups)	12	23.2296	1.9358		
Total	14	147.0738	10.5053		

3.5.Linear Regression Test (T-test)

T-test between the measurements of dissolved nutrients in leakage water in which Humic Acid and Ammonium Sulphate [$(NH_4)_2SO_4$]:

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	119.7	84.8	35.2	8e-5
Error (within groups)	6	5.3	0.4		
Total	10	144	12.5		

T-test between the measurements of dissolved nutrients in leakage water in which Humic Acid and Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]:

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	123.8	61.9	32	0.00002
Error (within groups)	6	23.2	1.9		
Total	10	147.1	10.5		

T-test between the measurements of dissolved nutrients in leakage water in which Ammonium Sulphate [$(NH_4)_2SO_4$] and Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$]:

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	129	64.5	33.3	0.00001
Error (within groups)	6	23.2	1.9		
Total	10	152.2	10.9		

4.Conclusion & Evaluation

4.1. Evaluation

In order to analyse, if there was a correlation between the type of fertilizer used and their negative effects on freshwater regimes due to leakage of excess irrigation water, I tested three different types of fertilizers and also compared the effect of increasing the concentration of the fertilizers to see if excessive use of fertilizers to gain more harvest has an effect on the environment. I than conducted ANOVA and T-test to validate the difference between the measurements with a statistical viewpoint. In the investigation, 45 individual experimentation setups were used. Due to economic reasons, 3 flowerpots were available, so each flowerpot was used 15 times, and in each trial, plants were grown for 15 days. Therefore, the experimentation solely required 225 days for the replantation and growth of the plants. 45 glass jars were used to collect excess water in each trial. At the end of the process, a special device was used to evaluate the nitrogen, sulphur, and phosphorus content of the excess water in the jars. The readings were recorded and used to plot the graphs above for better comparison.

From the graphs plotted above, it is possible to say that different fertilizers have different impacts on the environment. To make a comprehensive evaluation I would like to focus on every fertilizer individually.

First, the organic fertilizer used was humic acid, to make the experiment more realistic I used increased concentrations to illustrate the use of fertilizers in the agriculture to obtain better products faster. After ratioing the advised amount of fertilizer that should be used by the Agriculture and Forest Ministry[10] for meter cube of soil, I increased the concentration of the fertilizer by the same range of 10 $gm^{-2.}$ However, as seen on both the tables and the graph above, increasing the concentration of humic acid did not result in a change in the concentrations of excess sulphur and phosphorus were recorded to be same, whereas the nitrogen content increased. The reason behind the increase is the composition of the fertilizer itself. Humic acid is an organic fertilizer that consist of the faeces of farm animals mainly. Animal faeces are rich in nitrogen and relatively poor in phosphorus and sulphur according to the National Library of Medicine.[11] Therefore, no matter the concentration the amount of sulphur and phosphorus in excess water was constant at 0.01 $mgdm^{-3.}$ On the other hand, the amount of dissolve nitrogen in excess irrigation water increased with increasing humic acid concentration.

One of the two inorganic (chemical) fertilizers used was Ammonium Sulphate [$(NH_4)_2SO_4$], the fertilizer was rich in nitrogen and sulphate content. Therefore, increasing the concentration of the fertilizer used resulted in a gradual linear increase in the amount of dissolved nitrogen and sulphur in the excess irrigation water, meanwhile as the fertilizer does not have phosphorus in its composition there was no dissolved phosphorus found in the excess water of any of the different concentration of fertilizer used.

The other inorganic fertilizer used was Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$], this fertilizer is also rich in nitrogen however, instead of sulphur Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] is rich in phosphate. As a result, a gradual increase was also seen in the dissolved nitrogen and sulphur in excess water with the increasing concentration, however as there is no phosphorus in the composition of Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] there was no measured phosphorus in the excess water in any of the different concentrations.

To make a comparison between the two inorganic fertilizers, it was recorded that the runoff water in systems in which Ammonium Sulphate [$(NH_4)_2SO_4$] was used had a higher concentration of dissolved nitrogen compared to runoff water in systems where Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] was used. The reason behind this result is the difference in the percentage of nitrogen ions in each chemical. Although thy have relatively similar percentages Ammonium Sulphate [$(NH_4)_2SO_4$] is composed of 21% nitrogen ions whereas Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] is composed of 18% . This is thought to be the reason behind the result obtained.

To evaluate the effectiveness and accuracy of the results and comment on the hypothesis I compared the values I obtained with the values obtained in different investigations and values obtained from real life examples of eutrophication. According to World Health Organization[12], when the amount of dissolved nitrogen surpasses 5 gdm^{-3} the water is fragile and intoxicated that will probably lead to eutrophication. Therefore, it is creatin that the excess use of chemical fertilizers over the advised amount by authorities in this case Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] and Ammonium Sulphate [$(NH_4)_2SO_4$] is deadly to environment. Meanwhile it is relatively much more ethical and environmentally friendly to use organic fertilizers in this case humic acid as the nitrogen content of excess water does nor even surpass 1$mgdm^{-3.}$

Furthermore, in the case of dissolved phosphorus according to an article (Billen et al. 1999)[13] when the phosphorus levels in water ecosystems surpass 7 $mgdm^{-3}$ the water is considered to be polluted and requires treatment to not pose a danger to marine life. However, dissolved phosphorus in water ecosystems over 9 $mgdm^{-3}$ is regarded to be highly polluted and a definite threat to marine life and requires urgent action. The experiment I conducted suggests that overdose of fertilizers containing phosphorus such as Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] in this case is considered to have deadly consequences.

Finally for dissolved sulphur in freshwater ecosystems, in an investigation in Lake Taihu[14], researchers concluded that values below 10 $mgdm^{-3}$ are classified as not harmful and do not pose a threat to the environment. Therefore, use of fertilizer Ammonium Sulphate [$(NH_4)_2SO_4$]

do not pose a threat to the environment as a sulphur source as the dissolved amount do not overpass 10 $mgdm^{-3}$.

In the light of results, the hypothesis was mostly accepted. As the results suggest that increasing the amount of fertilizer used significantly increase the amount of excess nutrients in runoff water. The comparisons made between the inorganic fertilizers and the organic fertilizer were proved to be true. Graphs 1,2 and 3 show a clear increasing trend in excess nutrients in the excess water. However, it could also be said that the use of fertilizers that contain multiple chemicals that are more harmful to the environment is must not be favoured as seen in the case of Diammonium Hydrogen Phosphate [$(NH_4)_2HPO_4$] and Ammonium Sulphate [$(NH_4)_2SO_4$].

To gain more expected, realistic, and relevant data and improve the experiment done, far more trials should be performed, and some specific errors should be prevented. For instance, conducting only three trials is not enough to comprehend the issue. Different soil types, different vegetation and different water regimes must be examined to derive a definite answer to the question in hand. Furthermore, real life examples must be considered as laboratory experiments are idealistic and does not take into account outside factors such as the farmers, other animals, and plants in the area.

On the other hand, although it was not the question in hand, it was seen that using inorganic fertilizers proved to have a better growth in the vegetation. However, the consequences of adding inorganic chemicals and the advantages and disadvantages in might have to the human life through consumption and the effects it may have to the quality and the texture of the soil must be all taken into consideration when deriving an answer om whether to continue using chemical fertilizers.

Finally, another limiting factor would be the lack of diversity in types of fertilizers, there are more than 20 types of fertilizers that are used in agriculture and hundreds of brands that manufacture fertilizers. A more comprehensive investigation with a more flexible economic budget must be used to better understand the issue in hand.

4.2. Conclusion

As I stated before this study gave out expected results and supported the hypothesis to be correct, by conducting t-test and ANOVA tests, which the p values suggest that enough difference was obtained between the measuring from different concentrations of fertilizers. The graphs and tables displayed the expected trend. However, the investigation was not enough to fully understand the use of fertilizers in agriculture. As the study was limited to a single soil type, a single crop and was too idealistic to assemble a real-life example of a farm. Also, the positive effect of using chemical fertilizers in crop growth and efficiency where not taken into consideration in this investigation.

To conclude, it could be said that this study shows the clear difference in the amount of dissolved nutrients in the leakage water that blends in with freshwater ecosystems to pose a threat to the lives of the marine animals and plants due to the use of excess chemical fertilizers. Even though there is a variety of different variables that could be tested, this investigation fulfilled my desire to compare the effect of organic fertilizers and chemical fertilizers on the freshwater ecosystems when they are used excessively.

5.Bibliography

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