Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 1, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

SOIL PROPERTIES IN BRATEȘ FISH FARM: EFFECTS OF AGRICULTURAL USE ON PHYSICOCHEMICAL PARAMETERS

Carmelia Mariana BĂLĂNICĂ DRAGOMIR, Alina Crina MUREȘAN, Mirela CREȚU, Marian Tiberiu COADĂ

"Dunărea de Jos" University of Galați, 47 Domnească Street, Galați, Romania

Corresponding author email: mirela.cretu@ugal.ro

Abstract

This study aimed to investigate the physicochemical properties of soil from the Brateș Fish Farm, focusing on the effects of converting fishponds into agricultural land. The research examines explicitly how aquaculture practices impact key soil properties. To achieve this, soil samples were collected using standard procedures during the summer season and stored in polythene bags. Using standard analytical methods, these samples were analyzed in the laboratory for several physicochemical parameters, including pH, electrical conductivity, total soluble salts, and the concentration of Mg^{2+} and Ca^{2+} ions. In addition, the study assessed moisture content and soil porosity to evaluate the impact of land use changes on soil quality. The results of this study provide valuable insights into the long-term effects of aquaculture on soil characteristics and offer important considerations for the future agricultural use of such converted lands.

Key words: *agricultural use, converting fishpond, physico-chemical parameters, soil.*

INTRODUCTION

Soil properties have a crucial role in keeping the ecosystem balanced as well as agricultural productivity. In a fish farm, changes in soil physicochemical properties are expected due to the involvement of food residues and fish excrement, which may affect nutrient cycling, organic carbon content, and various aspects of soil quality. Fish farming has been shown to contribute considerable amounts of organic and inorganic waste, along with nutrient loads and other residuals to the environment (Matijevic et al., 2006). These discharges may intensify nutrient enrichment (Olsen et al., 2008; Zhang et al., 2015), accelerating the process of eutrophication (Petersen et al., 2016) and soil deterioration (Mavraganis et al., 2020). Moreover, these changes primarily deteriorate water quality, adversely impact fish health and growth performance (Raman, 2018), which ultimately compromises the sustainability of fish farming. In this context, the conversion of fish ponds to agricultural land is essential to investigate soil recovery processes. Crop production, nitrogen cycles, and soil composition interact intricately throughout this transition from aquatic habitats to farmland.

This paper aimed to analyze the physicochemical parameters of soil from the Brateș Fish Farm, focusing on the effects of fishpond-to-agriculture conversion. Integrating aquaculture practices with soil properties is a necessity for sustainable land development at the Brateș Fish Farm, where fish farming and agriculture coexist. The deposition of excess nutrients due to fish waste and feed residues has led to alterations in soil pH, organic matter content, and the equilibrium level of important minerals. Therefore, the present study emphasizes important soil properties, such as soil porosity and moisture content, electrical conductivity (EC), total soluble salts (TSS), pH, alkalinity, and calcium and magnesium cation levels. By analysing these factors, the study seeks to understand the implications of previous aquaculture practices on the soil's suitability for agricultural production and to provide insights into sustainable land management strategies for similar sites.

MATERIALS AND METHODS

Study area. The Brateș Fish Farm is a facility of the Institute of Research and Development for Aquatic Ecology, Fishing, and Aquaculture, and it is dedicated to the research and implementation of specific aquaculture technologies and the production of fish with superior productive qualities. The farm is located in the southern part of Lake Brates, near the Galati-Reni railway, in the meadow of the Prut River, in the northern part of Galați County, Romania (Figure 1) and it has a total area of 321.51 hectares, of which 292 hectares represent water surface (divided into several ponds for fish growth). Due to the declining fish productivity, it has been decided that certain ponds to be left dry for agricultural practices to improve soil properties. In this context, the present soil samples were collected after agriculture had been practiced in these fish ponds for 12 years.

Figure 1. Study area (Source: google maps)

Soil analysis. Soil samples were taken randomly from a depth of 20-25 cm using the closed-envelope method. In this sens, 500 g of soil was collected from each sampling point. All samples were collected during the summer season. The soil samples were placed in clean, labelled polyethylene bags and then transported to the laboratory for further analysis.

Table 1. Description of each sample based on the sampling stations

Sample (map point)	Land Use
S1	Grapevines
S2	Corn
S3	Vegetables
S4	Sunflower
S5	Reed

The collected samples were analyzed for the key physical and chemical soil quality parameters, including soil porosity and moisture content, electrical conductivity (EC), total soluble salts (TSS), pH, alkalinity, calcium, and magnesium cations levels.
Briefly, the soil porosity was determined by calculating the ratio of the volume of water absorbed by the material to its total volume. The result was expressed as a percentage (%) (Mureșan, 2018).

Soil moisture content was determined using the oven-drying method, as described by Su et al. (2014).
The EC of the soil was determined using a multi-parameter meter (multiEC-15). The total soluble salts content (TSS) in the soil was calculated using the following relation:

$$\text{TSS (g soluble salts per 100 g soil)} = \text{EC}\left(\frac{\text{mS}}{\text{cm}}\right) \times 0.3255,$$

where:
TSS is the total soluble salt content (g salts/ 100 g soil), and EC is the electrical conductivity (mS/cm).
The pH was determined based on the concentration of hydrogen ions (H^+) and hydroxide ions (OH^-) in the soil solution according to the procedure described by FAO (2021).
The total alkalinity of the soil was determined by the reaction of the soil solution with compounds such as bicarbonates and carbonates. It was measured by extracting an aqueous solution from the soil and titrating it with HCl (0.01 N), using methyl orange as the indicator. A color change at the endpoint indicates the alkalinity, and it is expressed as

milliequivalents H^+/100 g soil (Van Ranst et al., 1999).
Estimation of Calcium and Magnesium cations in soil samples was made according to El Mahi et al. (1987.

Statistical analysis. Statistical analysis was done using the statistical package for social science software SPSS statistical software for Windows, Version 26, United States, Chicago, SPSS Inc.

Data for the physicochemical parameters of soil samples were represented as mean values ± standard error of mean of the replicated samples (n=7). ANOVA was conducted to compare the results obtained for the physicochemical parameters of soil between the sampling points.

RESULTS AND DISCUSSIONS

Integrating agriculture practices in fish farm ponds has been recognized as a sustainable practice, especially for the recovery of soil properties. This study offers data regarding the most important physicochemical parameters and their effect on soil quality, particularly in the context of converting fishponds into agricultural land.

Determination of soil porosity and moisture content

The soil porosity and moisture content of the collected samples are presented in Figure 2. The obtained values for soil porosity indicate a variation across the different samples, with the significantly highest porosity observed in Sample 1 (13.5 ± 0.76%), where grapevines were cultivated, while the lowest porosity (9.5 ± 0.41%) was observed in S4, where sunflower was cultivated. No significant ($p>0.05$) differences were recorded in the porosity of the S2 (10.75 ±0.42 %), S3 (11.5 ± 0.74%), and S5 (10 ± 0.75%) samples, where the land was used for corn, vegetables, and reed.

Soil porosity refers to the volume of pores capable of holding water and air, which directly affects water retention, drainage, and the availability of oxygen to plant roots. The differences in soil porosity observed among the samples can be linked to different land use practices, notably the early involvement of aquaculture in the previous history of the soil. Soil provided from S1, which proved to have the highest porosity values, likely seems to benefit from natural regeneration. Generally, higher porosity increases water retention and aeration needed for plant growth, whereas low porosity indicates compaction of the soil or less space for water and air. Thus, these aspects can affect soil fertility as well as root growth. In contrast, soil from S4 likely experienced soil compaction, which suggests reduced pore spaces, hindering the soil's ability to hold water and air, potentially compromising sunflower root growth and overall soil fertility.

Regarding the moisture content of the analyzed samples, results showed significant variation with the land use ($p<0.05$). The lowest humidity content was recorded in the S4 samples (6.08 ± 0,39%), where sunflower was cultivated, while the highest humidity content was observed in the S3 samples (15.92 ± 0.47%), where vegetables were cultivated. No significant differences ($p>0.05$) were found between the moisture content of samples from grapevines (S1 – 13.63 ± 0.51%) and reeds (S6 – 13.92 ± 0.80%). The humidity content from S2 was significantly different from the other samples (7.96 ± 0.44%).

In the current study, soil from S1, which exhibited higher porosity, proved to have a moderate moisture content. Therefore, it is presumed that higher porosity has allowed a fairly good water retention capacity in the soil, ensuring sufficient water availability for plant absorption. On the other hand, the lowest porosity registered for S4 aligns with the lowest moisture content, suggesting the compaction of the soil, which can negatively impact both water retention and overall moisture availability for plant roots.

Also, the differences in the moisture content of the collected samples can be explained by the organic matter content from the soil, which is influenced by the previous practice of aquaculture. Aquaculture activities typically increase the organic matter in the soil due to the addition of organic materials such as fish waste and feed residues (Ackefors et al., 1994). This increased organic matter improves the soil's ability to retain water, which could contribute to higher moisture content in certain samples (Védère et al., 2022).

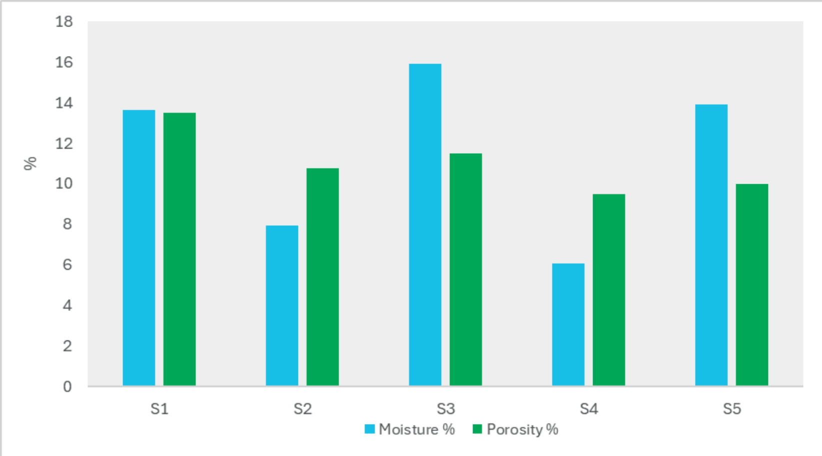

Figure 2. Soil porosity (%) and moisture content of the analyzed samples

Figure 3 presents the values of the Electrical Conductivity (EC) and the total soluble salts (TSS) for the analyzed samples. In our study, the highest value of EC was recorded in the S3 samples (0.72 ± 0.007 mS/s), followed by S5 soil (0.65 ± 0.0189 mS/s), with no significant differences (p>0.05). Also, no significant differences (p>0.05) were recorded in the values of EC for the samples S1 (0.40 ± 0.011 mS/s), S2 (0.43 ± 0.018 mS/s), and S3 (0.4 ± 0.018 mS/s).

Electrical conductivity (EC) measures the soil's capacity to conduct electric current and serves as a reliable indicator of nutrient availability. A higher EC generally suggests a greater presence of negatively charged particles, such as clay and organic matter, in the soil. Consequently, this results in increased retention of cations, such as sodium, ammonium, potassium, calcium, magnesium, hydrogen, iron, aluminum, copper, zinc, and manganese, all of which are essential for plant growth (Mureșan, 2018).

The results of our study indicate that soil from S3 and S5 samples, with higher EC, might be more effective in retaining essential nutrients, which could support plant growth. On the other hand, lower EC values, like those in S1, S2, and S4, indicate that the soil may have lower levels of dissolved nutrients, which could affect plant nutrient uptake and overall growth. According to the standard classification of EC values (Landon, 1991), soils with an EC between 0.51 and 1.25 mS/cm are considered appropriate for plant cultivation and thus, since the EC values in our study lie within this range, the soils analyzed can be classified as suitable for plant growth although those with higher EC values may retain more nutrients.

TSS refers to the total salt concentration in the soil solution and influences a range of soil parameters, like the hygroscopic coefficient, soil permeability to water, alkalinity, salinity, or soil buffering capacity (Mureșan, 2018). In our study the higher values of TSS were also recorded for the S3 (0.23 ± 0.007 g/100 g soil) and S5 (0.21 ± 0.003 g/100 g soil) samples, with significant differences (p<0.05) in comparison with the S1 (0.13 ± 0.011 g/100 g soil), S2 (0.14 ± 0.007 g/100 g soil) and S4 (0.14 ± 0.003 g/100 g soil).

The mean values of pH, Calcium, and Magnesium cations are presented in Figure 4.

Soil pH is an important parameter that influences nutrient availability for plants, microbial activity, and soil structure and is essential for plant growth and development (El-Ramady et al., 2014; Neina, 2019; Shi et al., 2021). No significant differences (p>0.05) were reported in the pH values between the soil samples collected. The highest pH values were found in the S5 (7.5 ± 0.022) sample, followed by the S1 (7.26 ± 0.03), S2 (7.26 ± 0.03), S4 (7.15 ± 0.01), and S3 (7.16 ± 0.01), respectively. However, the soil pH shows alkaline conditions, suitable for plant growth. Grapevines, corn, vegetables, and sunflowers generally perform well in soils with a pH of 6.0 to 7.5. Generally, reeds tend to prefer slightly alkaline conditions but grow very well at a pH of 7.5 (Khaled and Sayed, 2023).

Regarding the Ca and Mg cations, there were significant differences ($p<0.05$) recorded between the soil samples. The calcium cation levels vary across the soil samples, with the highest value observed in S5 (14.6 ± 0.41 mg/100 g soil). S1 (7.29 ± 0.29 mg/100 g soil) and S2 (6.01 ± 0.28 mg/100 g soil) have the lowest calcium values, while S3 (12.77 ± 0.07 mg/100 g soil) and S4 (11.78 ± 0.12 mg/100 g soil) show intermediate levels. The magnesium cation concentrations also vary, with S5 (17.43 ± 0.40 mg/100 g soil) showing the highest value, similar to calcium. The higher Ca and Mg cations from S5 are further associated with the increased values of pH. When the levels of Ca and Mg increase in the soil, these cations tend to neutralize hydrogen ions (H^+), which are responsible for soil acidity. Further, the Mg cations from S2 (12.14 ± 0.35 mg/100 g soil) are significantly different from those from S3 (6.6 ± 0.04 mg/100 g soil) and S4 (6.81 ± 0.07 mg/ 100 g soil). The Mg cations registered the lowest value in the S1 (3.12 ± 0.05 mg/100 g soil). These cations are very important in the physical, chemical, and biological enhancement of the soil, its structure-related improvement, the correction of soil acidity, and the mitigation of soil salinization.

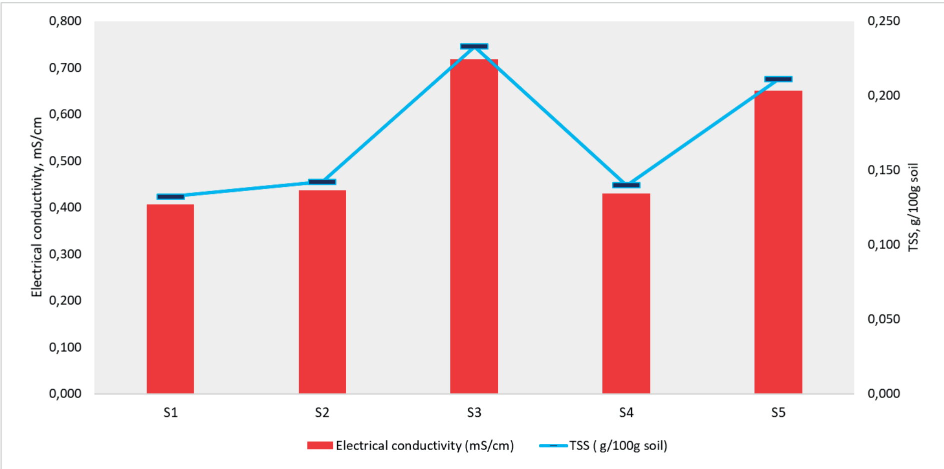

Figure 3. Electrical conductivity and total soluble salts of the analyzed samples

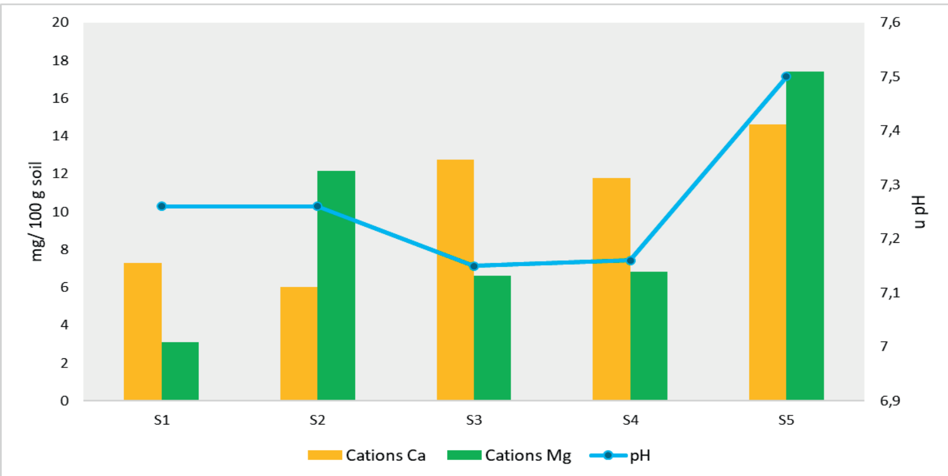

Figure 4. The pH and the Calcium and Magnesium cations of the analyzed samples

Figure 5 presents the soil alkalinity and salinity of the collected samples. Soil salinity is determined by the accumulation of soluble salts in the soil, leading to the formation of saline compounds. Alkalinity is determined by the sodium saturation of the soil's adsorptive complex, which, through reaction with water containing high levels of CO_2, generates sources of alkalinity by forming hydroxyl anions, resulting in sodic and alkaline soils (Zewd & Siban, 2021).

Alkalinity is a characteristic of the solution in saline, alkaline, and saline-alkaline soils. The alkalinity values of the soil samples ranged from 0.815 to 1.908 meq H^+/100 g soil, with the highest value recorded in sample S2 (1.91 ± 0. 003 meq H^+/100 g soil), and the lowest in sample S5 (0.81 ± 0.007 meq H^+/100 g soil). No significant differences ($p<0.05$) were recorded in the alkalinity of S3 (1.26 ± 0.007 meq H^+/100 g soil) and S4 (1.29 ± 0.007 meq H^+/100 g soil). Alkalinity reflects sodium saturation and influences soil buffering capacity. Higher alkalinity from S2 may affect plant growth by altering soil chemistry and reducing nutrient availability. In contrast, the lower alkalinity in S5 indicates better conditions for nutrient uptake.

Regarding the salinity of the soil samples, the highest salinity was recorded in the S3 (351 ± 4.18 mg/L), followed by the S5 (321 ± 3.64 mg/L). No significant differences ($p>0.05$) were recorded between S2 (210.6±3.08 mg/L), S4 (208±3.78 mg/L). The soil from S1 showed the minimum salinity (194.3±3.18 mg/L), meaning this area would accumulate very little salt due to good drainage, low evaporation, or less exposure to saline water sources.

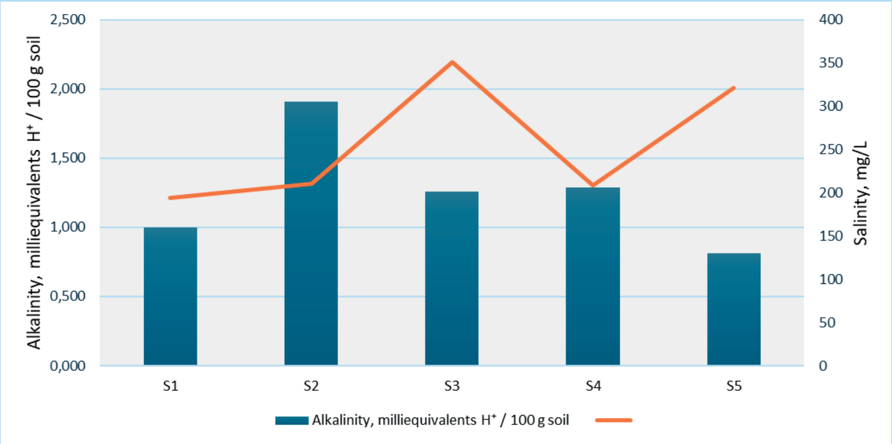

Figure 5. Alkalinity and salinity of the analyzed samples

CONCLUSIONS

This study highlights the impact of the integration of agricultural practices into fish farm ponds. Subsequently, 12 years after the fish ponds were left dry and agriculture was practiced, an improvement in the soil structure was observed. The analysis of soil physicochemical parameters demonstrates significant variations in porosity, moisture content, electrical conductivity, soluble salts, and cation concentrations, which are influenced by the previous land use practices of aquaculture activities. Certain samples show higher porosity and moisture contents, implying regeneration of the soil. It was observed that the pH of the soil samples was generally alkaline, which is good for plant growth. Calcium and magnesium cations have been found to improve soil structure and counteract acidity. Their higher concentrations in soil samples attest to suitable pH levels and improved conditions for the growth of plants. Therefore, the overall finding suggests that integrated agricultural practices in fish farm ponds can facilitate the recovery of soil quality in terms of the fertility and productivity of crops.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the Ministry of Agriculture and Rural Development, project ADER 13.1.1., Funding Contract No. 68990/21.06.2023- "Research on Increasing Profitability in Aquaculture Farms by Introducing Valuable Species with the Implementation of Specific Aquaculture, Zootechnical, and Agricultural Technologies – Establishment of the Integrated Aquaculture Farm".

REFERENCES

Ackefors, H., & Enell, M. (1994). The release of nutrients and organic matter from aquaculture systems in Nordic countries. *Journal of Applied Ichthyology, 10*(4), 225-241.

El Mahi, Y.E., Ibrahim, I.S., Abdel Magid, H.M., & Eltilib, A.M.A. (1987). A simple method for the estimation of calcium and magnesium carbonates in soils. *Soil Science Society of America Journal, 51*(5), 1152-1155.

El-Ramady, H.R., Alshaal, T.A., Amer, M., Domokos-Szabolcsy, É., Elhawat, N., Prokisch, J., & Fári, M. (2014). Soil quality and plant nutrition. *Sustainable agriculture reviews,* 14: Agroecology and global change, 345-447.

FAO. (2021). *Standard operating procedure for soil pH determination*. Rome, Italy.

Khaled, F., & Sayed, A. (2023). Soil pH and its influence on nutrient availability and plant health. International *Journal of Advanced Chemistry Research*, *5*(2), 61-63.

Landon, J.R. (1991). *Booker Tropical Soil Manual a Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics*. London, UK: Routledge Publishing House.

Matijevic, S., Kuspilic, G., & Baric, A. (2006). Impact of a fish farm on physical and chemical properties of sediment and water column in the middle Adriatic Sea. *Fresenius Environmental Bulletin*, *15*(9), 1058-1063.

Mavraganis, T., Constantina, C., Kolygas, M., Vidalis, K., & & Nathanailides, C. (2020). Environmental issues of Aquaculture development. *Egyptian Journal of Aquatic Biology and Fisheries, 24*(2), 441-450.

Mureșan, A.C. (2018). *Chemistry and soil pollution.* Galaţi, RO: University Press Publishing House.

Neina, D. (2019). The role of soil pH in plant nutrition and soil remediation. *Applied and environmental soil science*, 5794869.

Olsen, L.M., Holmer, M., & Olsen, Y. (2008). *Perspectives of nutrient emission from fish aquaculture in coastal waters. Literature review with evaluated state of knowledge*. FHF project, 542014, 87.

Petersen, J.K., Saurel, C., Nielsen, P., & Timmermann, K. (2016). The use of shellfish for eutrophication control. *Aquaculture International*, *24*, 857-878.

Raman, R.P. (2018). Organic Manuring in Freshwater Aquaculture and Its Impact on Pond Ecosystem and Fish Health: An Overview. *Journal of Aquaculture*, 1-21.

Shi, Y., Li, Y., Yang, T., & Chu, H. (2021). Threshold effects of soil pH on microbial co-occurrence structure in acidic and alkaline arable lands. *Science of the Total Environment*, 800, 149592.

Su, S.L., Singh, D.N., & Baghini, M.S. (2014). A critical review of soil moisture measurement. *Measurement, 54*, 92-105.

Van Ranst, E., Verloo, M., Demeyer, A., & Pauwels, J.M. (1999). *Manual for the Soil Chemistry and Fertility Laboratory-Analytical Methods for Soils and Plants, Equipment, and Management of Consumables*. Ghent, BE: NUGI 835.

Védère, C., Lebrun, M., Honvault, N., Aubertin, M. L., Girardin, C., Garnier, P., ... & Rumpel, C. (2022). How does soil water status influence the fate of soil organic matter? A review of processes across scales. *Earth-Science Review*s, 234, 104214.

Zewd, I., & Siban, M. (2021). The effects of alkalinity on physical and chemical properties of soil. *Journal of Plant Biology and Agriculture Science, 3*, 1-5.

Zhang, Y., Bleeker, A., & Liu, J. (2015). Nutrient discharge from China's aquaculture industry and associated environmental impacts. *Environmental Research Letters, 10*(4), 045002.