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"INFLUENCE OF CHEMICAL AND BIO-FERTILIZERS ON SOIL QUALITY AND AGRICULTURAL SUSTAINABILITY OF MAHAGOAN REGION, YAVATMAL DISTRICT, MAHARASHTRA INDIA "

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ABSTRACT

The sustainable management of soil quality is essential for long-term agricultural productivity. The Mahagaon region in Yavatmal District, Maharashtra, has a predominantly agricultural economy, where soil fertility and sustainability play a critical role in crop productivity. This study aims to assess the influence of chemical and bio-fertilizers on soil quality and agricultural sustainability in the region. Chemical fertilizers, though widely used, often lead to soil degradation, affecting long-term productivity, while bio-fertilizers present an eco-friendly alternative that may enhance soil health. The research involves a comparative analysis of soil physico-chemical properties, such as pH, organic carbon, nutrient availability (N, P, K S), and micronutrients (Zn, B, Fe, Mn, Cu), in fields treated with chemical fertilizers versus those treated with bio-fertilizers. Soil samples from three villages—Amboda, Gunj, and Dhanoda—were collected and analyzed for key soil properties after applying both chemical fertilizers (S1, S2, S3) and bio-fertilizers (S4, S5, S6).

KEYWORDS: Physico-Chemical Parameters, Fertilizers, Mahagoan Region, Soil Quality

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INTRODUCTION

Soil formation is a complex, gradual process influenced by the interplay of parent material, climate, organisms, topography, and time. Parent material affects soil's ability to retain water and organic matter, both vital for climate regulation [1]. Soil is a self-organizing system that supports plant and microbial growth, carbon sequestration, water movement, and habitats for microorganisms, all of which depend on its structure [2]. It begins with the weathering of rocks, which breaks them down into smaller particles that mix with organic matter from plants and microorganisms [3]. Climate plays a crucial role, as temperature and rainfall dictate the rate of weathering and organic decomposition. Topography influences water drainage and erosion, while living organisms contribute to nutrient cycling and soil structure. Over time, these factors shape soil's physical and chemical properties, making it a dynamic and essential medium for supporting agriculture and ecosystems [4, 5].

Agricultural productivity is the cornerstone of food security and rural livelihoods in India, with soil quality being a critical factor influencing crop yield and sustainability. Maharashtra's agricultural productivity is closely tied to monsoon rainfall, as much of the region depends on rain-fed agriculture. Irrigation facilities are crucial in areas with less reliable rainfall. The overuse of chemical fertilizers and water scarcity in some parts of the state has led to soil degradation, affecting long-term productivity. However, there is a growing shift towards sustainable agricultural practices, including the use of bio-fertilizers, organic farming, and soil conservation techniques, which are helping to maintain soil health and enhance productivity in the region [6, 7].

In regions like Mahagaon in Yavatmal district, Maharashtra, where agriculture forms the backbone of the local economy, maintaining soil health is vital for long-term agricultural sustainability. The rapid adoption of chemical fertilizers in the post-Green Revolution era has contributed significantly to increasing crop yields. However, their prolonged and indiscriminate use has led to detrimental effects on soil health, including nutrient imbalances, reduced microbial activity, and soil degradation [8, 9].

In contrast, bio-fertilizers, which consist of living microorganisms, offer a more sustainable alternative by enhancing soil fertility through natural processes [10]. These include nitrogen fixation, phosphorus solubilization, and the stimulation of plant growth-promoting rhizobacteria. Bio-fertilizers improve soil structure, promote the retention of essential nutrients, and support the long-term health of the soil ecosystem without the adverse environmental impacts associated with chemical inputs [11, 12].

The Mahagaon region, characterized by its predominantly agrarian economy, relies on cotton, soybean, and other cash crops that are

Research Paper

heavily influenced by soil fertility [13]. This region offers a pertinent case study for evaluating the impact of chemical and bio-fertilizers on soil quality. This research seeks to investigate how these fertilizers influence key physico-chemical properties of the soil, such as pH, organic matter content and nutrient availability. Additionally, the study aims to assess how these changes in soil health impact agricultural sustainability in the region, providing insights into best practices for maintaining soil quality while ensuring high crop productivity [14, 15].

MATERIALS AND METHODS

Study Area

The study was conducted in the Mahagaon region of Yavatmal District, Maharashtra, India in Figure 1. [16] This region is primarily agricultural, with varying soil types and farming practices. Three villages Amboda, Gunj, and Dhanoda were selected for sample collection due to their diverse agricultural activities and use of different fertilizer practices, including both chemical and bio-fertilizers.

Sample Collection

Soil samples were collected from six different locations: three from fields treated with chemical fertilizers (S1: Amboda, S2: Gunj, S3: Dhanoda) and three from fields treated with bio-fertilizers (S4: Amboda, S5: Gunj, S6: Dhanoda). For each location, soil samples were collected from the top 15 cm of soil, which is the active root zone where most nutrient interactions occur.

Analysis of Soil Sample

The samples were collected in sterilized polythene pouches air-dried, sieved, and analyzed for various physico-chemical properties, including soil pH was measured in a 1:2.5 soil-to-water suspension using a pH meter, while electrical conductivity (EC) was determined in the same extract using a conductivity meter. Organic carbon content was analyzed using Walkley and Black's wet oxidation method. Available nitrogen (N) was estimated by the Kjeldahl method [17], phosphorus (P) by Olsen's method using a spectrophotometer, and potassium (K) was measured using a flame photometer. The available micronutrients, including zinc (Zn), iron (Fe), copper (Cu), and manganese (Mn), were analyzed by using an atomic absorption spectrophotometer (AAS) to determine the concentrations of these micronutrients [18, 19].

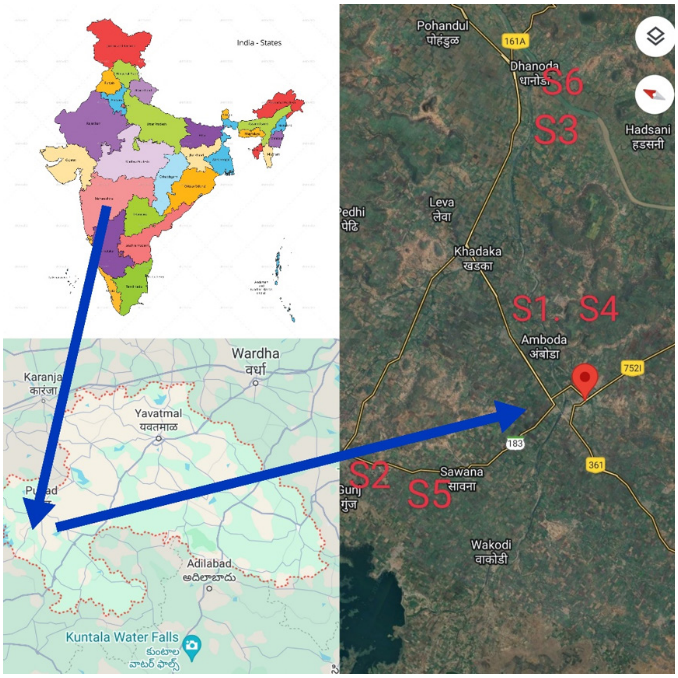


Figure 1: Map of Study area Mahagoan region

RESULT AND DISCUSSION

The results from soil samples treated with chemical and bio-fertilizers across three villages (Amboda, Gunj, and Dhanoda) in the Mahagaon region reveal distinct differences in various physico-chemical properties of the soil. These variations are key indicators of soil health and are discussed below:

Soil pH: The pH values for chemical fertilizer-treated soils (S1-S3) range from 7.55 to 8.18, indicating slightly alkaline soil conditions, especially in Gunj (S2) where the pH is highest (8.18). In contrast, the bio-fertilizer-treated soils (S4-S6) show relatively lower pH values, ranging from 7.3 to 7.95, suggesting a more balanced soil environment. The lower pH in bio-fertilizer-treated soils may be due to enhanced microbial activity, which promotes organic acid production, helping to regulate pH levels. The reduction in soil alkalinity under bio-fertilization is favorable for nutrient availability and microbial functions.

Electrical Conductivity (EC): The EC values reflect soil salinity, with chemical fertilizers showing higher values (0.57-0.63 dS/m) compared to bio-fertilizers (0.24-0.49 dS/m). The lower EC in bio-fertilizer-treated soils indicates a reduced risk of salinity stress, which is important for sustaining soil structure and crop productivity over time. The reduced salt accumulation in bio-fertilized soils suggests that these treatments may mitigate potential long-term soil degradation.

Organic Carbon (OC): Organic carbon content is a critical indicator of soil fertility. The bio-fertilizer-treated soils show slightly higher OC percentages (0.26%-0.47%) compared to chemical-fertilized soils (0.24%-0.45%). The enhanced organic carbon in bio-fertilized soils is likely due to the promotion of organic matter decomposition and microbial biomass, leading to improved soil structure, nutrient retention, and overall soil health. This aligns with the goal of improving soil sustainability through biological inputs.

Nitrogen (N): Soils treated with chemical fertilizers show higher nitrogen content, particularly in Dhanoda (S3), with 426.5 kg/ha, while bio-fertilizer-treated soils exhibit moderate levels, ranging from 301.1 to 363.8 kg/ha. Although chemical fertilizers provide an immediate nitrogen boost, bio-fertilizers contribute to more sustainable, slow-releasing nitrogen through processes like nitrogen fixation.

Phosphorus (P): The phosphorus content is relatively higher in bio-fertilized soils of Gunj (S5) at 25.9 kg/ha, compared to the chemical treatments (11.3-19.01 kg/ha). Bio-fertilizers, particularly phosphate-solubilizing bacteria, likely enhance phosphorus availability, which is crucial for root development and overall plant growth.

Potassium (K): Potassium levels are significantly higher in bio-fertilizer-treated soils, especially in Gunj (S5) and Dhanoda (S6) at 685.78 and 630.11 kg/ha, respectively, compared to chemical fertilizers (379.57-529.20 kg/ha). Bio-fertilizers help in mobilizing potassium, making it more accessible for plant uptake, which is vital for crop resistance and productivity.

Sulfur (S): Chemical fertilizers show higher sulfur content (15.90-19.18 ppm), whereas bio-fertilizers have slightly lower levels (11.49-20.67 ppm). While sulfur is essential for protein synthesis in plants, bio-fertilizer treatments still offer adequate sulfur, supporting balanced nutrient management.

Zinc (Zn): Bio-fertilizer-treated soils show considerably higher zinc levels, with Gunj (S5) reaching 1.02 ppm, compared to chemical-fertilized soils (0.21-0.74 ppm). Zinc is essential for enzyme function and growth, and the higher levels in bio-fertilized soils suggest improved zinc mobilization by microbes. Boron (B): Chemical fertilizers lead to slightly higher boron content, particularly in Gunj (S2), while bio-fertilized soils exhibit moderate boron levels. Proper boron levels are important for cell wall formation and reproductive growth, and the balanced boron observed in bio-fertilizer-treated soils indicates its sufficiency for crop requirements.

Iron (Fe): Bio-fertilizers significantly enhance iron availability, with Gunj (S5) recording the highest iron content (6 ppm) compared to chemical fertilizers (2.14-3.39 ppm). Iron is critical for chlorophyll synthesis, and the increased iron availability in bio-fertilized soils likely enhances plant health and photosynthetic activity.

Manganese (Mn): Chemical fertilizers contribute to higher manganese content in some cases, such as in Amboda (S1) with 10.34 ppm, whereas bio-fertilizers result in moderate to lower Mn levels. Despite the slight reduction in Mn levels, bio-fertilizers likely maintain sufficient manganese for crop growth.

Copper (Cu): Bio-fertilizers lead to higher copper concentrations, particularly in Amboda (S4) and Dhanoda (S6), which recorded 2.24 ppm and 2.43 ppm, respectively. Copper is essential for lignin formation and overall plant vigor, and bio-fertilizers seem to enhance its bioavailability.

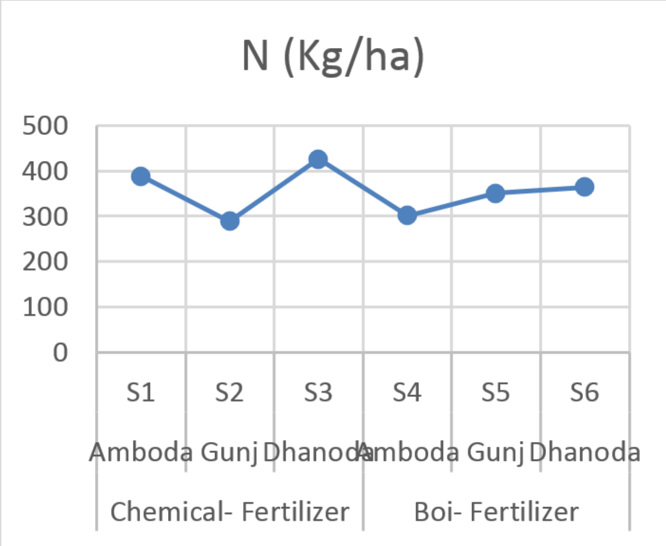
The results indicate that bio-fertilizers improve several key soil quality parameters compared to chemical fertilizers, particularly in terms of pH stabilization, organic carbon enrichment, and micronutrient availability (Zn, Fe, Cu). Bio-fertilizers enhance nutrient cycling and microbial activity, contributing to the long-term sustainability of the soil, while chemical fertilizers provide immediate nutrient boosts but may degrade soil health over time due to higher salinity (EC) and less microbial diversity.

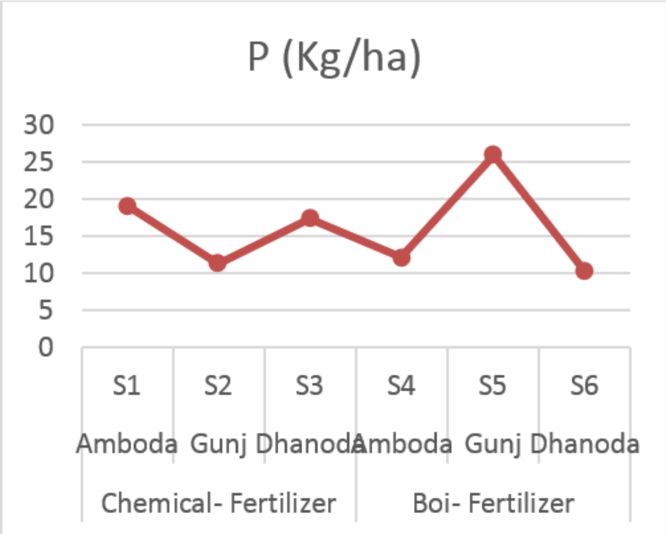
The increased availability of key nutrients such as nitrogen, phosphorus, potassium, and essential micronutrients in bio-fertilized soils underscores their potential in promoting agricultural sustainability in the Mahagaon region. These findings suggest that bio-fertilizers offer a more balanced, environmentally friendly approach to maintaining soil health, which can be critical for the region's long-term agricultural productivity.

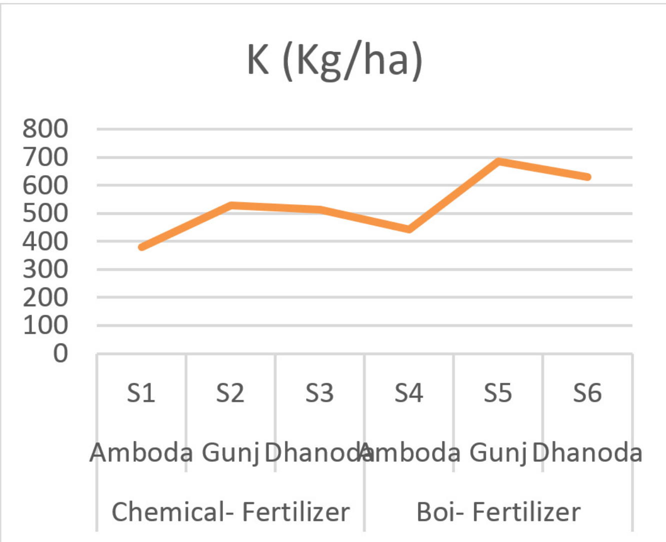
CONCLUSION

Overall, the findings suggest that bio-fertilizers offer a more sustainable approach to maintaining soil quality and promoting agricultural productivity in the Mahagaon region. While chemical fertilizers provide immediate nutrient enhancement, their long-term use poses risks of soil degradation and reduced microbial diversity. Bio-fertilizers, with their ability to improve soil structure, nutrient cycling, and microbial activity, provide a viable solution for enhancing agricultural sustainability in the region. Adoption of bio-fertilizer practices could help maintain soil health, increase crop yields, and support the long-term viability of farming in the Mahagaon region.

Fertilizer	Chemical- Fertilizer			Boi- Fertilizer		
Sample	Amboda	Gunj	Dhanoda	Amboda	Gunj	Dhanoda
	S1	S2	S3	S4	S5	S6
PH	7.75	8.18	7.55	7.63	7.3	7.95
EC dS/m	0.62	0.57	0.63	0.47	0.24	0.49
OC %	0.45	0.24	0.38	0.47	0.26	0.44
N (Kg/ha)	388.9	288.5	426.5	301.1	351.2	363.8
P (Kg/ha)	19.01	11.3	17.36	12.12	25.9	10.19
K (Kg/ha)	379.57	529.20	513.41	441.95	685.78	630.11
S (ppm)	15.90	18.17	19.18	13.18	20.67	11.49
Zn (ppm)	0.21	0.29	0.74	0.78	1.02	0.72
B (ppm)	0.45	1.11	1.11	0.49	0.24	0.6
Fe (ppm)	2.83	2.14	3.39	4.2	6	3.41
Mn (ppm)	10.34	6.47	7.25	10.13	2.47	4.51
Cu (ppm)	0.53	1.75	0.25	2.24	1.62	2.43







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