Microbial Diversity in Gir Region Mango Orchards: A Physico-Chemical Perspective.

Nidhi Popat[1] andKiran Desmukh[2]
[1]Research Scholar, P.H.Goswami Science and Arts College , Kalol,Gujarat University,nidhiPopat71@gmail.com.
[2]Principal - P.H.Goswami Science and Arts College , Kalol,principalphg1966@gmail.com.
Corresponding address
NidhiPopat
[1]Research Scholar, P.H.Goswami Science and Arts College , Kalol,Gujarat University,
nidhiPopat71@gmail.com

Abstract:
This study examines the influence of management strategies on the variety of microorganisms in the rhizosphere and the physical and chemical characteristics of mango plantations. Specifically, it explores the physicochemical properties and microbial diversity within the soil of the Gir mango orchard, located in the Gir region of Gujarat, India. By analyzing soil samples from various depths and locations within the orchard, the study assesses parameters such as pH, organic carbon, nitrogen, phosphorus, potassium, and microbial diversity. The findings indicate significant variations in soil properties and microbial populations, including bacteria and fungi which are crucial for understanding the orchard's health and productivity. This research contributes valuable insights to the ongoing scholarly conversation surrounding sustainable agriculture, emphasizing the significance of organic management strategies in mitigating environmental consequences while promoting sustained agricultural productivity.
Keywords: Microial Diversity, bacteria, Fungi anctinomycetes, mango orchards, physico-chemical, rhizosphere microbial, Girrigion

Introduction:

The title "Physico-chemical and rhizosphere microbial diversity study of Gir region Mango orchard" implies a scientific inquiry into the surrounding soil of mango trees in the Gir region, focusing on the environmental conditions and microbial populations.

Physico-chemical refers to the examination of the physical and chemical characteristics of soil, including factors such as pH, nutrient composition, and moisture levels. Comprehending these factors is of utmost importance as they have a direct impact on the growth of plants and the activity of microorganisms in the soil.

The term "rhizosphere microbial diversity" pertains to the examination of microorganisms, encompassing bacteria, fungus, and other microbes, that inhabit the immediate

vicinity of plant roots. Microbial activity is highly concentrated in the rhizosphere because of the release of root exudates, which act as a food supply for numerous microorganisms.

Overall, the objective of this study is to investigate the abiotic (physico-chemical) and biotic (microbial) constituents of the soil within a mango orchard located in the Gir region. Conducted research of this nature is necessary in order to comprehend the ecological dynamics of orchard ecosystems, enhance agricultural methods, and potentially enhance the quantity and quality of mango crops.

Mango, scientifically known as *Mangiferaindica L.* and belonging to the Anacardiaceae family, is highly lucrative in tropical and subtropical areas across the globe. Cultivated for over 4,000 years in the Himalayan foothills of the Indian-Myanmar region, this crop is widely recognised for its exceptional taste, appealing aroma, and significant nutritious content. The consumption of mangoes can contribute significantly to the maintenance of a balanced human diet, as they offer around 64-86 calories of energy per 100 g. Moreover, regular consumption of mangoes can serve as a rich dietary source of numerous phytochemical components. This is Rodriguez Pleguezuelo. The experimental site of Almuñecar is situated in a specific location. In addition to various other components, the fruit possesses a high concentration of ascorbic acid, rendering it a highly beneficial source of vitamin C. The ascorbic acid level in the fruit ranges from 32 to 200 mg per 100 g of edible pulp. From 1991 to 2001, the cultivation of mangoes has shown a significant growth of 42.5%. This increase can be attributed to the rising demand for both fresh and processed mango products. The global fruit production is forecast to exceed 23.4 x 10^6 tonnes annually and is projected to grow.(Rodríguez Pleguezuelo et al., 2012)

About Rhizosphere

In 1904, Lorenz Hiltner, a German agronomic and plant physiologist, introduced the term "rhizosphere" to refer to the interface between plants and roots. The origin of this phrase can be traced back to the Greek word "rhiza", which translates to root. Hiltner (year) elucidated the rhizosphere as the anatomical zone encompassing the root of a plant, wherein a distinct assemblage of microorganisms resides. He hypothesised that this population is influenced by the chemical compounds emitted by the plant roots. Over time, the concept of the rhizosphere has been improved to encompass three distinct zones that are determined by their close proximity to, and consequent impact on, the root. The endorhizosphere comprises the cortex and endodermis, where bacteria and cations can inhabit the apoplastic space, which refers to the empty area between cells. The rhizoplane refers to the medial zone that is in close proximity to the root, encompassing the root epidermis and mucilage. The ectorhizosphere, which spans from the rhizoplane to the bulk soil, represents the outermost zone. The rhizosphere, due to the intricate and varied nature of plant root systems, does not possess a distinct size or shape. Instead, The root has a diverse array of chemical, biological, and physical attributes that exhibit variations in both radial and longitudinal directions.(McNear Jr., 2013)

Root Exudates and Mineral Nutrition

Plants react to a lack of nutrients by adjusting the structure of their roots, attracting microorganisms, and altering the chemical composition of the rhizosphere. The release of root exudates facilitates the absorption of nutrients by means of mechanisms such as acidity, redox modification, and chelation. Nitrogen and phosphorus, which are essential for promoting growth, are frequently augmented in soils as a result of their restricted accessibility. The absorption of ammonium results in the release of protons, leading to a decrease in pH. Conversely, the absorption of nitrate raises pH by creating bicarbonate. Changes in pH have an impact on the accessibility of micronutrients. Rhizobacteria that promote plant growth facilitate plant

development through several mechanisms, including root colonization, the production of growth-stimulating chemicals such as phytohormones and siderophores, as well as indirect mechanisms such as biocontrol and systemic resistance.

Research Aim and objectives:

Aim

To investigate microbial diversity and physico-chemical properties in mango orchards.

Objectives:

1. To assess rhizosphere microbial diversity.
2. To analyze physico-chemical properties of soil.

Review literature

(**Mukhtar et al., 2019**)Plant development and production are negatively impacted by abiotic stressors. In recent decades, researchers have shown a keen interest in the captivating microorganisms that inhabit the rhizosphere of plants thriving under challenging ecological conditions. The prevalence of bacterial phyla Actinobacteria, Proteobacteria, Firmicutes, and Bacteroidetes, as well as archaeal phyla Euryarchaeota and Crenarchaeota, is higher in the rhizosphere of plants farmed in severe environments. The rhizosphere microbiomes are of paramount importance in facilitating plant growth when faced with abiotic stressors. This is achieved by several mechanisms, including nitrogen fixation, generation of phytohormones, solubilization of minerals, synthesis of siderophores and HCN, as well as the activation of plant defence mechanisms against a range of bacterial and fungal diseases. Meta-omics methodologies, including metagenomics, metatranscriptomics, and metaproteomics , can be employed to investigate intricate mechanisms implicated in the mitigation of stress induced by microorganisms in various plant species thriving in challenging ecological conditions. These methodologies provide complex data that can result in significant results; therefore, there are greater opportunities for application in this domain. This investigation offers a thorough examination of the variety of archaea and bacteria found in the root microbiome of plants grown under extremely difficult conditions. In addition, we elucidated many pathways pertaining to the involvement of plant growth promoting microorganisms in the presence of abiotic stressors. Furthermore, we emphasized the potential applications of meta-omics methodologies in elucidating the ongoing progress in plant-microbe interactions.

(**Saeidyet al., 2021**) The aim of this study was to analyse the variations in microbial communities in different fruit tree orchards (namely mango, guava, ber, bael, jamun, aonla, and sweet orange) during the summer, rainy, and winter seasons of 2018-19 in a semiarid irrigated setting. The mango orchard had the highest levels of total bacterial carbon (TBC), polysaccharides (PSB), and nitrogen fixers in both the rhizosphere and non-rhizosphere throughout the summer and rainy seasons. Conversely, the jamun orchard displayed the highest fungal count throughout all seasons. The guava orchard exhibited the greatest abundance of actinomycete in both the summer and winter seasons, whereas the mango orchard displayed a higher concentration during the rainy season. The rainy season exhibited the highest levels of overall microbial count, phosphate solubilizing bacteria, and nitrogen fixers in both the rhizosphere and non-rhizosphere. Conversely, fungal and actinomycetes count was seen to be higher during the summer season. During the summer season, the mango orchard demonstrated the most significant augmentation in total microbial count, PSB, and nitrogen fixers or diazotrophs (11.61%, 7.88%, 7.67%), as well as during the rainy season (11.16%, 7.57%, 6.93%), in comparison to the control group. In contrast, the ber orchard had the lowest overall bacterial population, phosphate solubilizing bacteria, and nitrogen fixers count (20.03%),

followed by the guava orchard (10.25%) and the sweet orange orchard (13.58%). The jamun orchard exhibited the highest rise in fungal count compared to the control group throughout the summer season (25.77%), rainy season (21.83%), and winter season (33.44%). The guava orchard exhibited the highest increase in actinomycetes count compared to the control throughout the summer season (8.72%) and during the winter season (9.37%). In contrast, the mango orchard experiences a rainfall rate of 10.71%.

        (Wei et al., 2021) The involvement of soil microorganisms in various aspects of terrestrial ecosystems, Some examples of important topics include nutrient cycle, net primary production, food safety, and climate change, is of utmost importance. However, the impact of cover cropping in agroforestry systems on soil microbes has not been thoroughly investigated. In this study, a field experiment was done to evaluate the impact of covering crops with seeded grass strips on various aspects of a mango orchard, this research investigates various dimensions like fruit productivity and quality, composition of the community, and the variety of soil microbial taxa.The findings demonstrated that implementing a two-year cover cropping strategy resulted in a significant increase in both mango fruit yields and soluble solids content. The use of cover cropping resulted in an increase in soil fungal diversity, as opposed to soil bacterial diversity. While cover cropping did not have a substantial impact on soil bacterial diversity, it did have a major effect on the makeup of soil bacterial communities.

Soil nitrogen levels mostly influenced The fluctuations in the composition of soil fungal and bacterial communities have been documented, which can have either beneficial or negative effects on the relative abundance of both bacterial and fungal species. The implementation of cover cropping resulted in modifications to fungal guilds, resulting in a rise in the prevalence of poisonous fungi and a decline in beneficial fungi. One of the key factors to be taken into account in order to improve mango fruit yields and quality is the increase in fungal diversity and changes in fungal communities. The findings of our study demonstrate that cover cropping has an impact on both the quantity and quality of mango fruit by modifying soil fungal diversity. This research addresses a significant knowledge gap regarding the connections between soil biodiversity and fruit quality in orchard environments, specifically in relation to cover cropping.

Research methodology:

Study Area and Site Description

The research was carried out in the Gir region, renowned for its mango plantations. The region has a semi-arid climate, which is defined by high temperatures during the summer, mild temperatures during the winter, and moderate levels of rainfall. The major soil type in this region is silty clay loam, which is well-suited for growing mangoes. This study focused on two distinct categories of mango orchards: those that were managed using organic methods and those that were handled using conventional methods. Each category consisted of orchards with different ages and tree depths in order to examine the impact of these variables on soil characteristics and microbial variety.

Materials and Methods

Study AreaThe Gir mango orchard is located in the Gir region, Gujarat, India. The climate is tropical, with distinct wet and dry seasons, which influences soil characteristics.SoilSamplingSoil samples were collected from different depths (0-15 cm, 15-30 cm, and 30-45 cm) at multiple locations within the orchard to capture spatial variability. Each sample was air-dried, sieved, and stored for analysis.Physiochemical AnalysispH: Determined using a pH meter in a 1:2.5 soil-water suspension. Organic Carbon: Measured using the Walkley-Black method. Phosphorus: Extracted using the Olsen method and quantified

calorimetrically.Potassium: Measured using flame photometry after extraction with ammonium acetate.Microbial Diversity AnalysisMicrobial Count: Total bacterial and fungal counts were determined using serial dilution and plating on nutrient agar and potato dextrose agar, respectively

Sampling Procedure

Nine soil samples were obtained from distinct locations throughout each orchard, ensuring a full depiction of the study region. The samples were collected from various depths in order to examine the variation in soil qualities as a function of depth. The study focused on analysing the microbial communities in the rhizosphere soil, which is the soil that sticks to the roots, and is affected by the substances released by the roots.

Physico-Chemical Analysis

The physico-chemical properties of the soil, including pH, electrical conductivity (EC), total nitrogen, total phosphorus, potassium concentration, and cation exchange capacity (CEC), were measured. Bulk density and porosity were also assessed to understand the physical structure of the soil. These parameters were analyzed using standard soil analysis techniques:

pH and EC Measurement: Soil pH was measured using a digital pH meter, and EC was determined using an EC meter.

Microbial Population and Diversity: The number and type of bacterial and fungal species, their functional characteristics (e.g., phosphate solubilization, siderophore production), and their growth-promoting properties were analyzed.

RESULTS:

Properties: pH Ranged from slightly acidic to neutral (6.2-7.5), indicating suitable conditions for mango cultivation.Organic Carbon: Varied from 0.5% to 1.2%, reflecting differences in organic matter content.Nitrogen: Levels ranged from 0.05% to 0.15%, suggesting varying nitrogen availabilityPhosphorus: Available phosphorus content varied between 10 to 25 mg/kg.Potassium: Potassium levels ranged from 150 to 300 mg/kg, indicating sufficient potassium for mango growth.Microbial DiversityBacterial Population: Dominated by genera such as *Bacillus, Pseudomonas,Azotobacter* and *Rhizobium,* essential for nutrient cycling and plant growth promotion.Fungal Population: Predominantly comprised of *Aspergillus, Penicillium, and Trichoderma*, which play roles in organic matter decomposition and disease suppression.Microbial Community Structure: Significant diversity observed, with variations in microbial populations correlated with soil depth and physiochemical properties.

.

Figure 1: Soil physicochemical analysis of mango plants
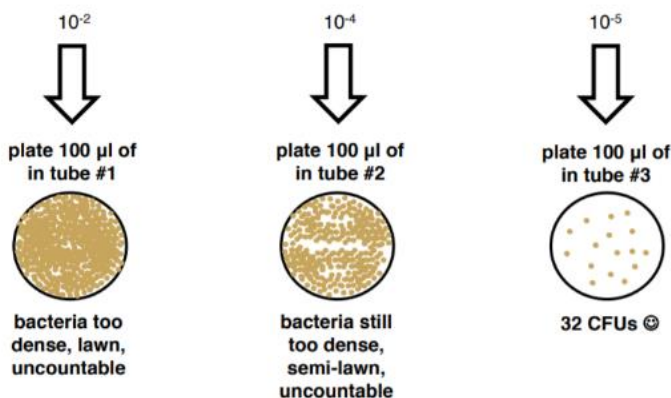
Fig: 2 Standard plate count

Fig: 3 Nitrogen Fixing Bacteria

:

Table: 6 Total Bacterial count CFU/g

samples no	samples specification	Total Bacterial count CFU/g
sample 1	maniya	7.4×10^{-8}
sample 2	moniya near runing water	5.8×10^{-8}
sample 3	chaparda near running water	7.0×10^{-8}
sample 4	Dadar near temple	7.8×10^{-8}
sample 5	medarda	6.5×10^{-8}
sample 6	gir village resort, Nani Khodiyar	8.4×10^{-8}
sample 7	malanka	5.8×10^{-8}
sample 8	shivam farm surajgadh	6.2×10^{-8}
sample 9	sasan	6.1×10^{-8}

The data table provided presents the overall bacterial count in Colony Forming Units per gramme (CFU/g) for different samples obtained from various places. The bacterial counts vary

between 5.8×10^{-8} and 8.4×10^{-8} CFU/g, suggesting the existence of significant bacterial populations in these regions.

Sample 1 was obtained from Maniya and exhibits a bacterial count of 7.4×10^{-8} colony-forming units per gram (CFU/g). The relatively high count indicates substantial bacterial activity, potentially caused by environmental conditions that promote bacterial growth.

Sample 2, collected from Moniya in close proximity to flowing water, exhibits a bacterial count of 5.8×10^{-8} colony-forming units per gram (CFU/g). The close proximity to flowing water may contribute to the presence of bacteria, as these conditions often offer a favourable home for bacteria due to the presence of moisture and nutrients.

Sample 3, obtained from Chaparda in close proximity to flowing water, indicates a bacterial concentration of 7.0×10^{-8} colony-forming units per gramme (CFU/g). Like Sample 2, the existence of flowing water probably sustains a varied and concentrated bacterial population.

Sample 4, collected from Dadar in close proximity to a temple, exhibits the most elevated bacterial population of all the samples, measuring at 7.8×10^{-8} CFU/g. The elevated amount of germs in the temple area can be linked to increased human activity and the resulting waste, which serves as a rich source of nutrients for bacterial growth.

Sample 5, obtained from Medarda, exhibits a bacterial count of 6.5×10^{-8} colony-forming units per gram (CFU/g). The count is moderate and represents the usual environmental conditions of the area, without any unique factors that greatly enhance or inhibit bacterial development.

Sample 6 was obtained from the Gir Village Resort in Nani Khodiyar and showed the highest bacterial count of 8.4×10^{-8} CFU/g. The resort's natural environment, characterised by abundant greenery and potential human presence, is likely responsible for the elevated bacterial population.

Sample 7, obtained from Malanka, exhibits a bacterial count of 5.8×10^{-8} CFU/g, which is equivalent to the bacterial count of Sample 2. This consistency implies that there are comparable environmental conditions or impacts shared by both locales.

Sample 8 is sourced from Shivam Farm in Surajgadh and exhibits a bacterial count of 6.2×10^{-8} CFU/g. The farm's agricultural characteristics may account for the significantly elevated bacterial count, which can be attributed to the presence of soil bacteria and organic matter commonly found in such environments.

Sample 9, obtained from Sasan, exhibits a bacterial count of 6.1×10^{-8} colony-forming units per gram (CFU/g). Similar to other rural or natural environments mentioned, Sasan's surroundings are likely conducive to a thriving bacterial ecosystem, as seen by the significant number of bacteria present.

Graph: 1 Graphical representation of Total Bacterial count CFU/g
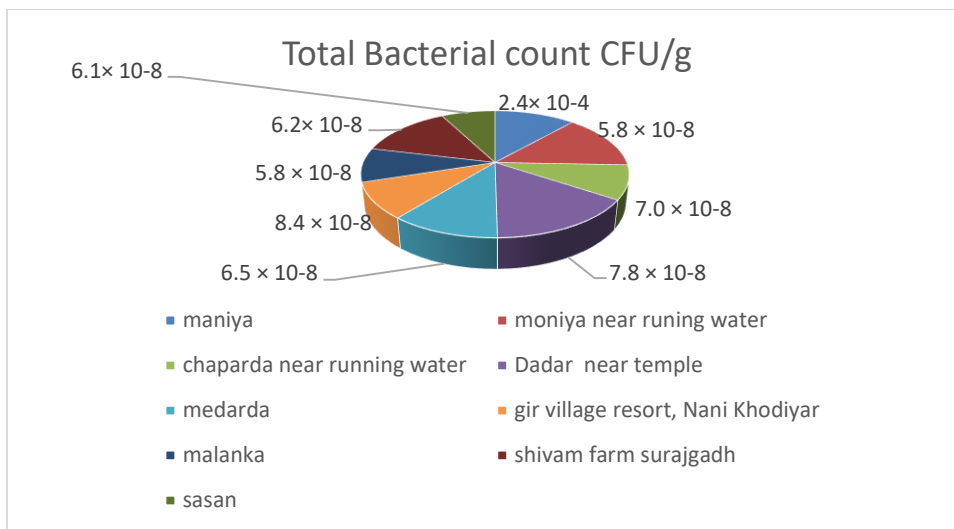
Table: 7 Total Fungi count

Samples no	Samples specification	Total Fungi count
sample 1	maniya	$2.4 \times 10\text{-}4$
sample 2	moniya near runing water	$2.9 \times 10\text{-}4$
sample 3	chaparda near running water	$1.8 \times 10\text{-}4$
sample 4	Dadar near temple	$3.2 \times 10\text{-}4$
sample 5	medarda	$2.3 \times 10\text{-}4$
sample 6	gir village resort, Nani Khodiyar	$1.9 \times 10\text{-}4$
sample 7	malanka	$1.8 \times 10\text{-}4$
sample 8	shivam farm surajgadh	$2.8 \times 10\text{-}4$
sample 9	sasan	$1.6 \times 10\text{-}4$

The data provided displays the cumulative number of fungus, measured in Colony Forming Units (CFU), for distinct samples obtained from diverse places. The fungal populations in these conditions exhibit a wide range, with counts ranging from $1.6 \times 10\text{-}4$ to $3.2 \times 10\text{-}4$ CFU.

The fungus count of Sample 1 from Maniya is $2.4 \times 10\text{-}4$ CFU. The count indicates a moderate level of fungi, which may be affected by local environmental conditions such as the presence of moisture and availability of organic material.

Sample 2, obtained from Moniya in close proximity to flowing water, exhibits a fungal count of $2.9 \times 10\text{-}4$ CFU. The close proximity to flowing water is likely to create an advantageous environment for the growth of fungi, as it maintains a constant level of moisture.

Sample 3, collected from Chaparda in close proximity to flowing water, indicates a fungus level of $1.8 \times 10\text{-}4$ CFU, which is rather low. Although Sample 2 shares comparable environmental

conditions, the prevalence of fungi may be influenced by additional factors such as soil composition and vegetation.

Sample 4, collected from Dadar in close proximity to a temple, exhibits the greatest fungal concentration, measuring at 3.2×10^{-4} CFU. The increasing number of fungi may be attributed to the heightened human presence near the temple, resulting in greater amounts of organic waste and dampness, which create favourable conditions for fungal proliferation.

Medarda's Sample 5 exhibits a fungal count of 2.3×10^{-4} CFU. The moderate count is indicative of the usual environmental conditions in the area, which foster a well-balanced fungus population.

Sample 6, obtained from the Gir Village Resort in Nani Khodiyar, had a fungal count of 1.9×10^{-4} colony-forming units (CFU). The resort's natural environment, although favourable for mushrooms, does not offer as many suitable conditions as certain other areas, leading to a comparatively lesser number of fungi.

Sample 7 from Malanka also has a fungal count of 1.8×10^{-4} CFU, which is the same as that of Sample 3. This closeness implies that there are similar environmental conditions that affect the growth of fungi in both of these places.

Sample 8, obtained from Shivam Farm located in Surajgadh, exhibits a fungus count of 2.8×10^{-4} CFU (colony-forming units). The farm's agricultural environment, abundant in organic matter, is likely to foster a larger population of fungi.

Sample 9 obtained from Sasan has the minimum fungal count of 1.6×10^{-4} CFU. This may suggest less advantageous circumstances for fungus, such as reduced moisture levels or distinct soil characteristics in comparison to the other areas.

Graph: 2Total Fungi count

Graph: 2Total Fungi count
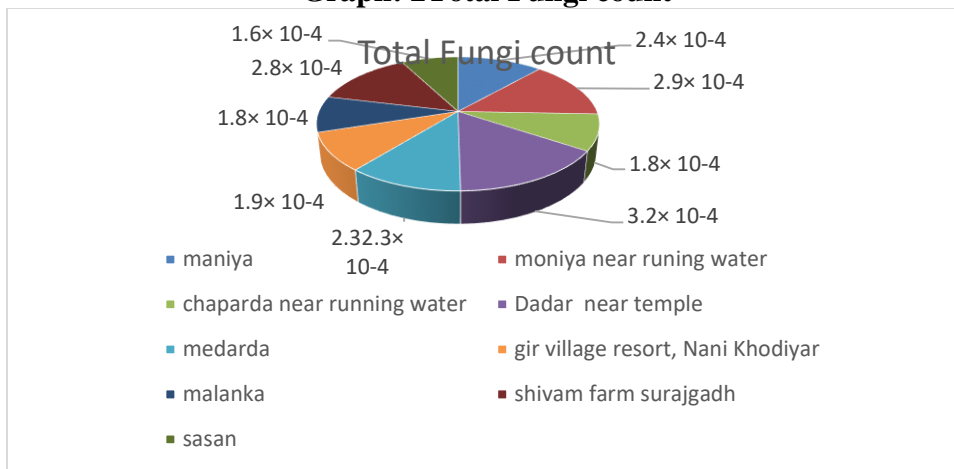
Table: 8Total N2 fixing bacteria

Samples no	Samples specification	Total N2 fixing bacteria
sample 1	maniya	8.2×10^{-3}
sample 2	moniya near runing water	5.3×10^{-3}

sample 3	chaparda near running water	4.2×10^{-3}
sample 4	Dadar near temple	5.6×10^{-3}
sample 5	medarda	6.3×10^{-7}
sample 6	gir village resort, Nani Khodiyar	7.2×10^{-8}
sample 7	malanka	3.2×10^{-9}
sample 8	shivam farm surajgadh	6.8×10^{-10}
sample 9	sasan	3.6×10^{-11}

The data presented provides specific information on the overall number of nitrogen-fixing bacteria in Colony Forming Units (CFU) in distinct samples obtained from diverse locales. The counts of nitrogen-fixing bacteria exhibit a wide range, ranging from a maximum of 8.2×10^{-3} to a minimum of 3.6×10^{-11} CFU. This indicates notable disparities in the occurrence of these bacteria among the studied habitats.

Maniya's Sample 1 exhibits the largest concentration of nitrogen-fixing bacteria, measuring 8.2×10^{-3} CFU. The elevated count indicates that the conditions in Maniya are particularly favourable for the proliferation and functioning of nitrogen-fixing bacteria, which play a vital role in enhancing soil fertility and promoting plant growth.

Sample 2, obtained from Moniya in close proximity to flowing water, exhibits a nitrogen-fixing bacteria population of 5.3×10^{-3} CFU. The existence of flowing water is expected to create a favourable environment, albeit not as ideal as in Maniya, resulting in a significant yet reduced number of microorganisms.

Sample 3, collected from Chaparda in close proximity to flowing water, indicates a count of 4.2×10^{-3} colony forming units (CFU). Although the environmental conditions in Sample 2 are identical, the lower count could be attributed to variations in water quality, soil composition, or other local factors that impact bacterial development.

Sample 4, collected from Dadar in close proximity to a shrine, exhibits a count of 5.6×10^{-3} colony forming units (CFU). These findings indicate that the vicinity of the temple offers a favourable habitat for nitrogen-fixing bacteria, possibly because of the existence of organic waste and other conditions that enhance bacterial activity.

Sample 5 from Medarda exhibits a markedly reduced level of 6.3×10^{-7} CFU. The significant decrease observed in comparison to the previous samples suggests that the nitrogen-fixing bacteria are experiencing fewer favourable conditions, potentially caused by a decrease in organic matter or less suitable soil qualities.

Sample 6, obtained from the Gir Village Resort in Nani Khodiyar, indicates a concentration of 7.2×10^{-8} colony-forming units (CFU). The resort's natural habitat seems to be unsuitable for a large population of these bacteria, maybe because certain environmental variables restrict their growth.

Malanka's Sample 7 exhibits an even lower level of 3.2×10^{-9} CFU. This indicates highly adverse conditions for nitrogen-fixing bacteria, potentially caused by substandard soil quality, depleted nutrient levels, or other inhibitory factors.

The count of Sample 8 from Shivam Farm in Surajgadh is 6.8×10^{-10} CFU. Although farms usually have increased bacterial activity due to organic matter, the low count of bacteria in this case suggests that the local conditions are not suitable for the growth of nitrogen-fixing bacteria. Sample 9 obtained from Sasan has the minimum count of 3.6×10^{-11} CFU. The remarkably low figure indicates that Sasan's surroundings are the least conducive to the presence of nitrogen-fixing bacteria compared to the other locations studied, either due to exceptionally unfavourable soil conditions or other detrimental environmental variables.

Graph: 3 Total N2 fixing bacteria
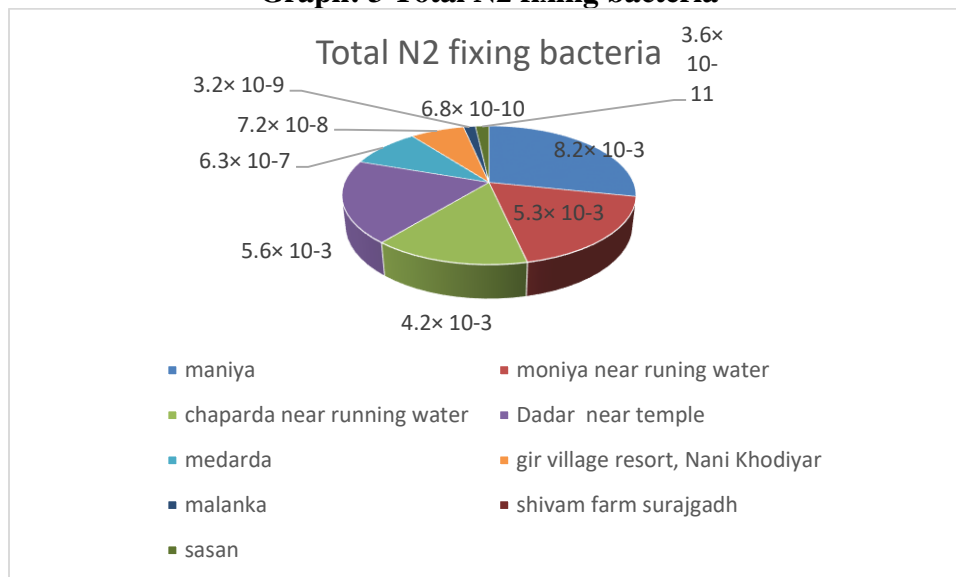
Table: 9 Morphological characteristics of Isolates

Morphological characteristics of Isolates						
Number of Bacteria	Gram Staining	shape	colony margin	Elevation	texture	pigmentation

NP1	G+ve	Rod	even	raised	moist	white
NP2	G+ve	Rod	irregular	flat	dry	off white
NP3	G+ve	Rod	irregular	flat	dry	off white
NP4	G+ve	Rod	even	raised	moist	white
NP5	G-ve	short Rod	even	raised	moist	greenish
NP6	G+ve	Rod	undulate	raised	moist	white
NP7	G-ve	short Rod	even	convex	moist	pink
NP8	G+ve	Rod	irregular	flat	moist	white
NP9	G+ve	Rod	even	raised	moist	white
NP10	G-ve	short Rod	even	flat	moist	nil
NP11	G+ve	Rod	irregular	convex	dry	off white
NP12	G+ve	Rod	undulate	raised	moist	white
NP13	G+ve	Rod	irregular	flat	dry	white
NP14	G-ve	short Rod	even	raised	moist	nil
NP15	G+ve	spherical	even	convex	moist	yellow
NP16	G+ve	Rod	undulate	raised	moist	white
NP17	G+ve	sperical	even	convex	moist	golden yellow
NP18	G+ve	Rod	irregular	flat	dry	white
NP19	G-ve	short Rod	even	raised	moist	nil
NP20	G+ve	Rod	irregular	flat	dry	white
NP21	G+ve	spherical	even	raised	moist	white
NP22	G-ve	short Rod	even	convex	moist	white
NP23	G+ve	Rod	irregular	flat	dry	white
NP24	G+ve	Rod	irregular	flat	moist	white
NP25	G+ve	Rod	undulate	raised	moist	white
NP26	G-ve	short Rod	even	convex	dry	white
NP27	G+ve	spherical	even	raised	moist	translucent
NP28	G-ve	short Rod	even	convex	dry	white
NP29	G+ve	Rod	irregular	flat	dry	white
NP30	G+ve	spherical	even	raised	moist	white
NP31	G-ve	short Rod	even	flat	moist	nil
NP32	G+ve	Rod	undulate	raised	moist	white

NP33	G+ve	Rod	irregular	flat	moist	white
NP34	G-ve	short Rod	even	slightly raised	moist	nil
NP35	G+ve	Rod	irregular	powdery	dry	white
NP36	G+ve	big Rod	even	raised	moist	white
NP37	G+ve	Rod	even	flat	dry	white
NP38	G+ve	Rod	irregular	flat	dry	white
NP39	G+ve	curve Rod	weaving /irregular	raised	dry	white
NP40	G+ve	Rod	even	convex	dry	white
NP41	G-ve	Short Rod	even	raised	moist	nil
NP42	G-ve	Short Rod	even	raised	moist	nil

The offered table offers a comprehensive overview of the morphological attributes of different bacterial isolates, distinguished by their sample numbers (NP1 to NP42). The characteristics encompass Gram staining results, bacterial morphology, colony border, elevation, texture, and pigmentation.

The isolates display a combination of Gram-positive (G+ve) and Gram-negative (G-ve) bacteria. The reported shapes include rods (most prevalent), shorter rods, and spherical (coccus) forms. NP39 is specifically characterised as a curved rod. There are 30 Gram-positive bacteria and 12 Gram-negative bacteria among the isolates described.

Table: 10samples specification

sample no	samples specification	pH	EC	WHC %	Moisture	soil type	Total Carbon %	Phosphorus	potassium
sample 1	maniya	7.9	0.66	71	68%	black lomy	0.51	24	125
sample 2	moniya near runing water	7.3	0.6	75	61%	black loamy	0.38	22	158
sample 3	chaparda near running water	8.1	0.65	70	68%	black loamy	0.17	20	126
sample 4	Dadar near temple	7.8	0.75	72	66%	black loamy	0.4	24	146
sample 5	medarda	7.9	0.35	69	65%	black loamy	0.56	11	124
sample 6	gir village resort, Nani Khodiyar	7.7	0.45	76	69%	black loamy	0.38	12	138
sample 7	malanka	7.3	0.6	68	62%	black loamy	0.66	26	114
sample 8	shivam farm surajgadh	7.4	0.26	72	64%	black loamy	0.36	21	154

sample 9	sasan	7.1	0.56	76	62%	black loamy	0.47	11	118

An analysis has been conducted on soil samples gathered from different sites, with a specific focus on pH, electrical conductivity (EC), water holding capacity (WHC), and moisture content. These characteristics are essential for comprehending the fertility and appropriateness of soils for agricultural and horticultural applications.

pH:

The pH values of the soil samples range from 7.1 to 8.1, indicating that all the soils have a neutral or slightly alkaline nature. Sample 3 from Chaparda, which is located near running water, had the highest pH level of 8.1. This high pH level may have an impact on the availability of nutrients, especially micronutrients. Sample 9 from Sasan exhibits the lowest pH value of 7.1, which falls below the neutral zone and is good for the majority of crops. The remaining samples demonstrate pH levels ranging from 7.3 to 7.9, indicating generally favourable conditions for the growth of plants.

Electrical conductivity (EC):

The electrical conductivity (EC) of the soil, which indicates its salinity, varies from 0.26 to 0.75 dS/m. Elevated electrical conductivity (EC) levels can be indicative of higher salt content, which can have a detrimental impact on plant growth. The sample with the greatest electrical conductivity (EC) value is obtained from Dadar, specifically near the temple (Sample 4), measuring at 0.75 dS/m, indicating elevated saline levels. Conversely, the sample obtained from Shivam Farm Surajgadh (Sample 8) had the lowest electrical conductivity (EC) at 0.26 dS/m, suggesting a lower amount of salinity. The majority of samples have electrical conductivity (EC) values that fall within a range that is generally deemed appropriate for the majority of crops.

The Water Holding Capacity (WHC):

The Water Holding Capacity (WHC) of the soil ranges from 68% to 76%, indicating its ability to hold water. The samples from Gir Village Resort, Nani Khodiyar (Sample 6), and Sasan (Sample 9) had the highest WHC, which is measured at 76%. The high water holding capacity (WHC) of these soils indicates their ability to efficiently store water, making them advantageous in areas with unpredictable precipitation patterns. The sample from Malanka (Sample 7) has the lowest water holding capacity (WHC) at 68%, indicating a relatively lower ability to retain water.

Moisture Content:

The moisture content of the soil, indicating the amount of water present, varies between 61% and 69%. The sample obtained from Gir Village Resort, Nani Khodiyar (Sample 6), exhibits the maximum moisture content of 69%, which corresponds to its elevated water holding capacity (WHC). Sample 2, taken from Moniya near running water, exhibits the lowest moisture content at 61%. This could be attributed to environmental conditions or soil qualities that influence water retention. Additional specimens exhibit diverse moisture levels, suggesting disparities in the accessibility of water among different areas.

Soil Type:

All of the samples have been classified as black loamy soil. Black loamy soils are nutrient-rich, possess excellent water retention capabilities, and are widely regarded as optimal for agriculture due to their well-balanced composition of sand, silt, and clay.

Total Carbon %:

The carbon content in the samples varies between 0.17% and 0.66%. The sample from Malanka (Sample 7) had the greatest carbon content, measuring at 0.66%. This suggests a potentially significant presence of organic matter, which might positively impact soil structure and fertility.

Sample 3, taken from Chaparda near running water, exhibits the lowest carbon concentration at 0.17%. This indicates a lesser presence of organic matter, which could potentially impact soil health and productivity. Additional samples exhibit different degrees of carbon content, with Medarda (Sample 5) and Maniya (Sample 1) displaying relatively high percentages of 0.56% and 0.51%, respectively.
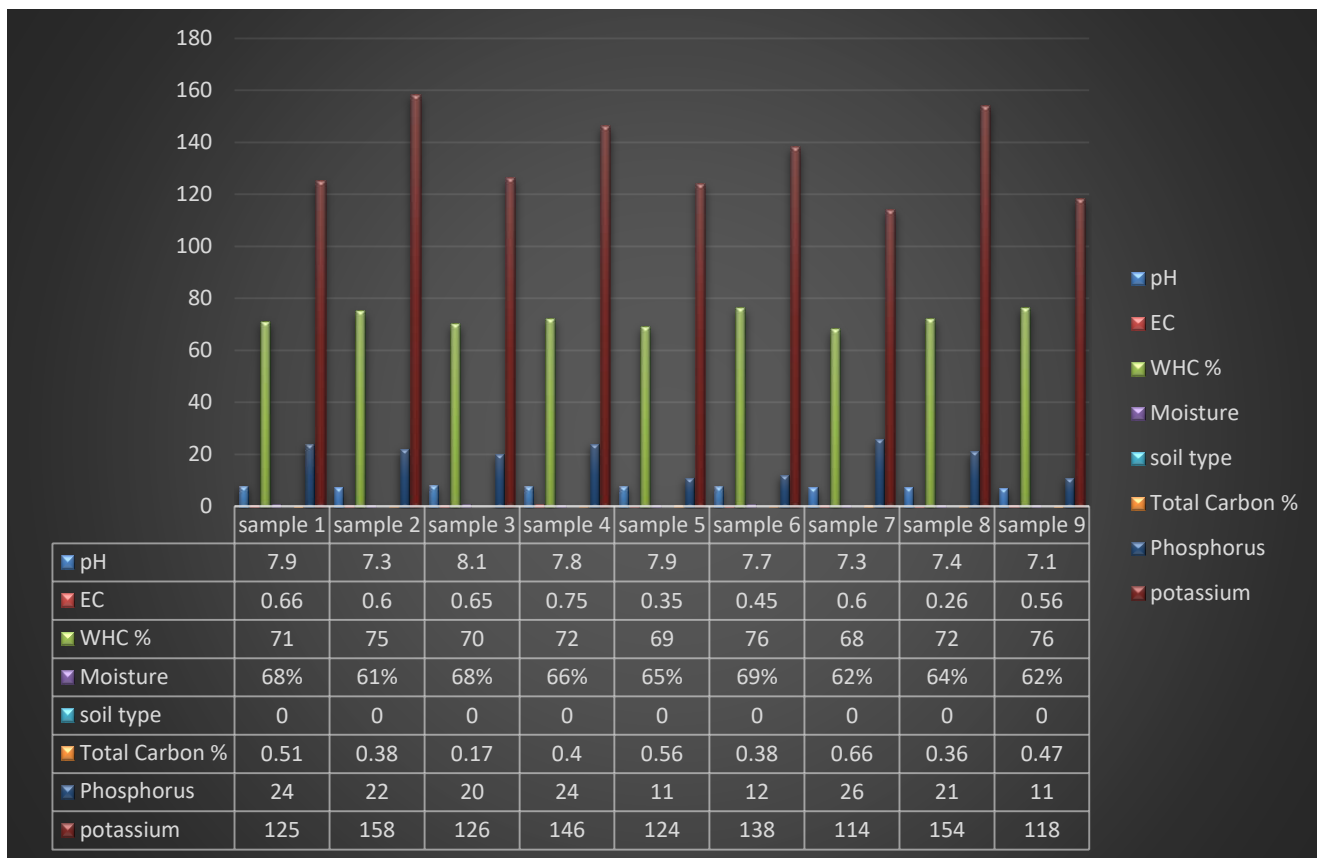
Phosphorus:

Phosphorus concentrations in the samples vary from 11 parts per million (ppm) to 26 ppm. Sample 7, obtained from Malanka, exhibits the greatest phosphorus level at 26 ppm, suggesting a favourable supply of this vital mineral for plant growth, particularly for root development and energy transfer. The samples from Medarda (Sample 5) and Sasan (Sample 9) exhibit the lowest phosphorus levels, measuring at 11 ppm. These levels may potentially restrict plant growth if not supplemented. The samples collected from Dadar near the temple (Sample 4) and Maniya (Sample 1) exhibit greater phosphorus levels at 24 ppm, indicating sufficient supply for most crops.
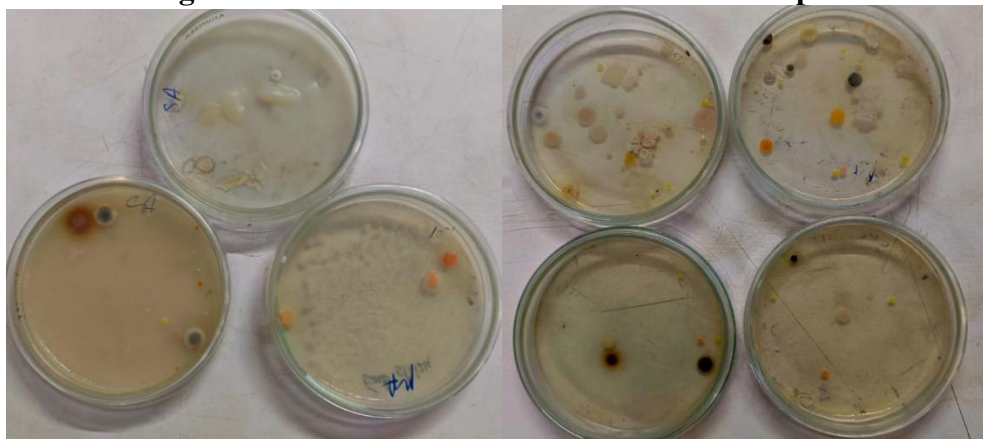
Potassium:

The samples exhibit a range of potassium content, with concentrations ranging from 114 parts per million (ppm) to 158 ppm. The sample from Moniya near running water (Sample 2) exhibits the greatest potassium level at 158 ppm, which is advantageous for plant health, disease resistance, and overall growth. The sample from Malanka (Sample 7) had the lowest potassium concentration, measuring at 114 ppm. Although it is the lowest, this level is within a range that is capable of sustaining robust plant development. Additional samples demonstrate different levels of potassium, with Shivam Farm Surajgadh (Sample 8) and Dadar near the temple (Sample 4) displaying significantly elevated potassium concentration at 154 ppm and 146 ppm, respectively.
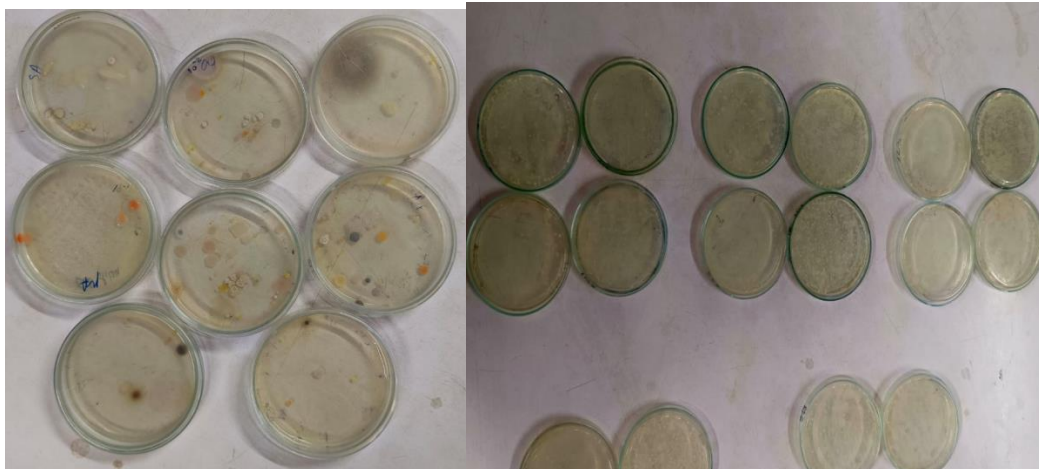
Graph: 4 samples specification.

	sample 1	sample 2	sample 3	sample 4	sample 5	sample 6	sample 7	sample 8	sample 9
pH	7.9	7.3	8.1	7.8	7.9	7.7	7.3	7.4	7.1
EC	0.66	0.6	0.65	0.75	0.35	0.45	0.6	0.26	0.56
WHC %	71	75	70	72	69	76	68	72	76
Moisture	68%	61%	68%	66%	65%	69%	62%	64%	62%
soil type	0	0	0	0	0	0	0	0	0
Total Carbon %	0.51	0.38	0.17	0.4	0.56	0.38	0.66	0.36	0.47
Phosphorus	24	22	20	24	11	12	26	21	11
potassium	125	158	126	146	124	138	114	154	118

Fig 5. Bacterial colonies from different soil samples

Discussion
The study reveals a complex interplay between soil physiochemical properties and microbial diversity. The neutral pH and adequate levels of essential nutrients indicate healthy soil conditions conducive to mango cultivation. The presence of beneficial microbes like *Bacillus , Azetobacter* Nitrogen fixing bacteria and Fungi suggests a biologically active soil environment that can support plant health and productivity. These findings underscore the importance of maintaining soil health through sustainable practices such as organic amendments and reduced chemical inputs

Conclusion
The Gir mango orchard soil exhibits diverse physiochemical and microbial characteristics that are crucial for its productivity. Understanding these properties can help in formulating effective soil management strategies to enhance mango yield and quality. Future research should focus on long-term monitoring and the impact of different agricultural practices on soil health and mango production

The study underscores the importance of organic management practices in enhancing rhizosphere microbial diversity and soil health. Sustainable agricultural practices are crucial for maintaining soil fertility and promoting environmental sustainability in mango orchards.

REFERENCE
1. Garg, N., Bhattacherjee, A. K., Shukla, P. K., & Singh, B. (2021). Influence of imidacloprid on bacterial community diversity of mango orchard soil assessed through 16S rRNA sequencing-based metagenomic analysis. *Environmental Monitoring and Assessment*. https://doi.org/10.1007/s10661-021-08885-7
2. Kumar, D., Dalal, R. P. S., Kumar, R., Parshad, J., & Jaipal, J. (2021). Seasonal Variation in Microbial Communities in Rhizosphere and Non-Rhizosphere soil of Different Fruit Tree Species in Semiarid Irrigated Conditions of Haryana. *International Journal of Bio-Resource and Stress Management*. https://doi.org/10.23910/1.2021.2414
3. McNear Jr., D. H. (2013). The Rhizosphere - Roots, Soil and Everything In Between. In *Nature Education Knowledge*.
4. Mukhtar, S., Mehnaz, S., & Malik, K. A. (2019). Microbial diversity in the rhizosphere of plants growing under extreme environments and its impact on crop improvement. *Environmental Sustainability*. https://doi.org/10.1007/s42398-019-00061-5
5. Rodríguez Pleguezuelo, C. R., Durán Zuazo, V. H., Muriel Fernández, J. L., & Franco Tarifa, D. (2012). Physico-chemical quality parameters of mango (Mangifera indica L.)

fruits grown in a mediterranean subtropical climate (SE Spain). *Journal of Agricultural Science and Technology*.

6. Saeidy, S., Petera, B., Pierre, G., Fenoradosoa, T. A., Djomdi, D., Michaud, P., & Delattre, C. (2021). Plants arabinogalactans: From structures to physico-chemical and biological properties. In *Biotechnology Advances*. https://doi.org/10.1016/j.biotechadv.2021.107771

7. Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture Circular, 939

8. Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science, 37(1), 29-38

9. Wei, Z., Zeng, Q., & Tan, W. (2021). Cover cropping impacts soil microbial communities and functions in mango orchards. *Agriculture (Switzerland)*. https://doi.org/10.3390/agriculture11040343