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A Physico-Chemical Evaluation of Agricultural Soil Across Villages in Narwana, Jind District, Haryana, India.

Dr. J. P. Deshwal[1*], Shalender Nain[2]

[1]Assistant Professor, Department of Chemistry, K.M. Government College, Narwana, Jind, Haryana, India.
[2]Assistant Professor, Department of Geography, K.M. Government College, Narwana, Jind, Haryana, India.
*Corresponding Author

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Abstract— *Since ancient times, India has existed as a deeply rooted agrarian civilization, with its initial societies flourishing near rivers and water sources. Farming serves as the foundation for crucial necessities like sustenance, forage, and protection. However, contemporary practices have overexploited natural elements, triggering an ecological imbalance. Perpetual cultivation without rest leads to a depletion of essential minerals required to feed a massive population. Furthermore, massive applications of synthetic fertilizers, weedkillers, and insect poisons alter the physical composition and inherent traits of the earth. The primary objective of this investigation is to restore soil texture by utilizing organic components such as livestock dung, vegetation remnants, and natural waste. A purely organic mixture named "Divya Amrit" is prepared to generate high-quality natural compost. This formulation aims to boost agricultural yields in both volume and quality while minimizing environmental degradation, moisture requirements, and synthetic chemical inputs. Embracing traditional Indian agricultural techniques offers an ideal pathway for generating adequate volumes of wholesome food and forage for humans and animals alike. To optimize crop production and manage land sustainably, understanding the variation in soil nutrients is essential. This study examines major and minor elements in the farming lands of the Narwana subdivision within Haryana's Jind district, adhering to BIS and ICAR protocols. Quantifying these nutrients was achieved using a UV-visible spectrophotometer, whereas a digital apparatus was employed to record electrical conductivity and PH. The research gauges current fertility levels and promotes organic soil modification. Ultimately, blending classic Indian agricultural tenets— like crafting homegrown manure— provides a straightforward method to decrease reliance on manufactured chemicals, mitigate environmental harm, and protect agricultural viability for the future.*

Keywords— ***micro nutrients, pH, electrical conductance, soil texture, soil sample, Spectrophotometer, concentration, sustainable agriculture.***

I. INTRODUCTION

As we know, human survival on Earth relies predominantly on agriculture. Roughly 70% of the global population depends upon farming, fruit cultivation, fish farming, beekeeping, livestock rearing, and connected agrarian sectors. A substantial portion of global workers choose farming out of a sense of autonomy, self-reliance, and an integration of contemporary mechanical tools. The deterioration of land due to aggressive farming practices presents a critical global issue that places ecosystems and food stability at risk. Globally, traditional modern farming frameworks rely heavily on chemical enrichments and pest controls to secure abundant harvests, frequently sacrificing long-term soil vitality. These contemporary farming methodologies bring about widespread complications, including the exhaustion of vital minerals, a drop in stable carbon or organic matter, increased acidity, and elevated salt concentrations, all of which damage the productive capacity of the land.

Farming zones in India, particularly within the highly productive Indo-Gangetic Plains, replicate these global difficulties in a more pronounced manner. Even though the

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Green Revolution historically elevated nationwide grain yields, decades of resource-heavy mono-cropping have induced severe soil fatigue. In Haryana, an essential agricultural territory, numerous investigations point to growing deficiencies in crucial trace minerals like boron and zinc, along with primary NPK macronutrients, declining organic carbon levels, and secondary salt accumulation. This regional crisis mirrors a broader countrywide trend, establishing a foundation for a detailed analysis of soil degradation.

Around the world, comparable degradation trends have sparked a transition toward regenerative farming focused heavily on soil health. Consequently, agricultural policy structures and academic studies increasingly support blended nutrient approaches and organic additives to regenerate soil capital in places like the European Union and North America. For instance, scientific validation shows that applying biomass, compost, and cover crops improves soil architecture, moisture retention, and microbial variety across distinct farming ecosystems. These international remedies emphasize the universal concept of nurturing the soil so the soil can nurture the crop— an idea deeply embedded in classic Indian farming heritage that is now receiving empirical validation.

Against this backdrop, the agricultural lands of Haryana's Jind district offer an essential case study. This investigation fills an analytical void by performing a multi-dimensional physicochemical evaluation of Narwana's soil to pinpoint current fertility states relative to domestic benchmarks and sustainable management theories. Identifying these traits facilitates the creation of locally tailored organic fixes. In Haryana, local folklore dictates that farming is the highest calling, commerce is average, employment or service is lowly, and begging is entirely shameful. From the dawn of society, humans have unceasingly gathered daily food and forage from the natural world through farming.

Satisfying the needs of an immense population with massive agricultural outputs demands over-cultivation, which induces soil damage via manufactured fertilizers and toxic pesticides, altering both pH and physical texture. Currently, the state of agrarian soil is highly degraded. It has become impossible to generate high-quality crops and forage in sufficient volumes using purely synthetic inputs and chemicals. The aforementioned diagnosis prompted this exploration of a localized natural remedy. Evaluation has focused on "Divya Amrit," a solution concocted naturally from cattle dung, animal urine, jaggery (gur), gram flour (besan), water as the dissolving agent, and earth gathered from beneath Banyan trees. This mixture serves as a vehicle for soil rejuvenation, leveraging livestock manure, plant biomass, and a collection of beneficial microbes. By steering data-driven soil science toward the practical deployment of traditional changes, this project seeks to deliver a scalable framework for soil preservation. Utilizing these localized resources can upgrade soil quality, diminish reliance on chemical additives, and synchronize Indian agricultural habits with global ecological targets, thereby ensuring both ecological wholeness and enduring food security.

II. REVIEW OF LITERATURE

Farming constitutes a vital segment of the international economic landscape. The surrounding environment exerts a powerful influence on this primary source of food, forage, and connected biological essentials. Various studies indicate that agriculture accounts for roughly 70% of freshwater utilization across most global territories (Baroni et al., 2007). The immense volume of manufactured agrochemicals utilized in farming, primarily as synthetic fertilizers and pest controls, introduces complications into natural ecosystems. Agriculture stands out as a massive consumer of water reserves and a major human-driven source of greenhouse gases (Wallace, 2000; Labedzki & Bak, 2017; Neethu et al., 2018; Piwowar & Harasym, 2020).

Subterranean water, rainfall, surface streams, lakes, and rivers supply the drinking, agricultural, and industrial needs of society. Roughly 12% of the global populace consumes 85% of the planet's groundwater, and this specific 12% resides outside the developing world (Barlow, 2001). Water availability dictates human settlement locations and societal actions, yet an expanding population places extreme pressure on pristine freshwater reserves. Physical and chemical pollution damages the quality of surface and underground water, originating from diverse origins such as the land-dumping of agricultural chemicals and organic waste, irrigation water filtering down through the earth, septic units, sewage plant seepage, pits, lagoons, and storage basins.

This specific project uses standard analytical procedures to perform a physical and chemical validation of farming soil samples. The Narwana zone within the Jind district has historically served as a primary "rice bowl" for Haryana. The core objective of this research is to evaluate salinity, pH, major nutrients, and trace elements within Narwana's agricultural zones. Endless farming without intervals, combined with the practice of setting crop remnants on fire, causes environmental pollution and depletes natural components within the earth.

Protracting agricultural activities without rest intervals triggers a decline in both the quality and volume of grain and crop outputs, presenting a critical danger to living creatures. A premier obstacle in contemporary farming involves creating enduring, productive structures capable of

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yielding superior food without endangering natural assets (de Oliveira et al., 2018). Furthermore, sustainable farming must maintain minimal contributions to global warming and greenhouse gas emissions (Sun et al., 2019). These combined challenges have driven the exploration of alternative biological enrichments and the execution of methods designed to seal the soil nutrient cycle (Chaturvedi & Therios, 2014).

Natural adjustments to the earth, using organic materials and minerals known for generations, can resolve these issues efficiently. All such soil modifications function as bases to refine the attributes of farmed lands, crop outputs, and overall fertility. They accomplish this by boosting nutrient and water availability for vegetation, limiting moisture loss, sustaining elevated micro-biological performance in the ground, and enhancing nutrient absorption by crops (Tu et al., 2006; Tejada et al., 2009; Xu et al., 2015; El-Alsayed & Ismail, 2017; de Oliveira et al., 2018).

III. STUDY AREA & SAMPLING

The geographical coordinates for the Narwana case study in the Jind district of Haryana, India, are 29.616667◦N and 33.116667◦E. This territory lies within the Indo-Gangetic zone, a region characterized by high-intensity farming operations. A collection of 25 separate samples from the Narwana subdivision (labelled N-1 through N-25) was gathered during January 2022. This collection followed a structured scientific protocol. At every target location, four random sub-samples were drawn from a depth of 0–30 cm utilizing a soil auger. These sub-samples were thoroughly combined into a uniform mixture to produce a single composite sample for that specific site. Roughly 250 grams of every blended sample were placed into a spotless, dry textile pouch, secured tightly, and sent to the laboratory for evaluation. This collection methodology was designed to map the spatial distribution of vital soil attributes across the subdivision's experimental farming landscape.

IV. MATERIAL & METHODS

Soil testing was conducted to identify crucial physical and chemical variables that signal land fertility and vitality. Every evaluation complied with the uniform methodologies laid out by the Bureau of Indian Standards (BIS) and the Indian Council of Agricultural Research (ICAR), focusing on the IS-2720 sequence and matching ISO- 18400 standards.

4.1. Analysis of Basic Parameters

The pH and electrical conductivity of the earth were evaluated through potentiometric means. A blend of soil and water was formulated by combining 12 grams of air-dried earth with 24 millilitres of distilled water, maintaining a 1:2 (w/v) proportion. This mixture was agitated thoroughly for 2 minutes and allowed to rest for 30 minutes prior to taking readings with calibrated electronic pH and conductivity instruments.

4.2. Analysis of Macro and Micronutrients

Evaluations were carried out to determine primary macronutrients— specifically available Nitrogen (N), Phosphorus (P), Potassium (K), and Sulphur (S)—along with micronutrients, including Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe), and Boron (B). Stable organic carbon levels within the soil were also quantified. These variables were measured via a UV-visible spectrophotometer using distinct colorimetric and extraction steps according to standard protocols outlined in Table-2. For instance, available phosphorus was isolated using Olsen's technique, available potassium was assessed via flame photometry alongside spectrophotometry, and trace elements were separated using a DTPA extraction before being measured with an atomic absorption spectrophotometer (AAS) or spectrophotometric analysis.

4.3. Data Analysis

The gathered metrics were arranged into tables and analysed descriptively to calculate the average, span, and degree of variation for every parameter across all 25 samples. The fertility status of the soil was interpreted using the baseline limits established for agricultural production by BIS and ICAR.

V. RESULT & DISCUSSION

The measured quantities for every soil sample mixture are detailed in the charts. Every conclusion adheres to BIS, ICAR, IS-2720 (ISO: 18400 sequence) benchmarks.

Table- 1: Analytical Methods and BIS/I.C.A.R. (IS-2720) Standards for Agricultural Soil Samples as established by: BIS, I.C.A.R. (IS-2720).

S.No.	Parameter	Method Employed	Desirable Limit	Maximum Limit
1	pH*	Digital pH Meter	7 - 7.50	7.50 – 8.50
2	EC**ds/m	Digital Conductometer	0.4 – 0.8	0.8 – 1.5
3	Organic Carbon(%)	Spectrophotometric Method	0.5 – 0.75	>0.75

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4	Nitrogen(Kg/Hectare)	Spectrophotometric Method	240 - 280	>480
5	Phosphorus(Kg/ha***)	Spectrophotometric Method	11 - 22	>22
6	Potassium(kg/ha)	Spectrophotometric Method	110 - 280	>280
7	Sulphur(mg/Kg)	Spectrophotometric Method	15 - 20	>100
8	Manganese(mg/Kg)	Spectrophotometric Method	10-20	20 - 3000
9	Zinc(mg/Kg)	Spectrophotometric Method	0.6 – 10**(DTPA)** 10 – 20**(Dry Matter)**	>10 >20
10	Iron(mg/Kg)	Spectrophotometric Method	6 – 10**(DTPA)** 18 – 21**(Dry Matter)**	>10 >21
11	Copper(mg/Kg)	Spectrophotometric Method	0.2 – 0.98**(DTPA)** 0.5 – 2.7**(Dry Matter)**	>0.98 >2.7
12	Boron(mg/Kg)	Spectrophotometric Method	0.48 – 24.25	>24.25

*pH (Power of Hydronium ion) -<6.5(Acidic), 6.5-7.5 (Normal), 7.5-8.5 (Slightly Alkaline), >8.5-9.0 (Moderately Alkaline), >9.0(Strongly Alkaline).

**EC (Electrical Conductance) – 0.4-0.8 (Non-Saline), 0.8-1.5 (slightly Saline), 1.5-2.0(Moderately Saline), >2.0(Strongly Saline).

***ha (Hectare)

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Table- 2: Soil Sample Data from Villages within the Narwana Sub-division

Sr NO.	Sample code	PH		Ec (dS/m)	Organic carbon OC%	Nitrogen available	Phosphorus (Kg /ha)	Potassium (Kg /ha)	Sulphur (mg\kg)	Manganese (mg\kg)	Boron(mg \kg)	Zinc mg/kg ZnHCl(D.W.)*	zinc mg/kg ZnDTPA	Iron mg/kg Fe- Hcl (D.W.)*	Iron mg/kg Fe- DTPA	copper mg/kg CuHCl	Copper mg/kg Cu- DTPA
1	N-1		8.56	0.825	0.135	75	10.6	35	54.63	24.04	1.21	4.9	2.1	17.1	5.9	4.1	1.3
2	N-2		8.5	0.7	0.11046	64	20.2	61	61.62	19.31	0.534	8.4	4.2	12.5	4.2	2	0.4
3	N-3		8.28	0.533	0.0882	49	31.7	54	92.35	26	1.27	6.7	3.3	16.4	5.3	0.9	0.2
4	N-4		7.98	0.634	0.2244	125	10	112	3.85	20.96	0.391	7.7	3.5	11.7	3.8	6.2	2
5	N-5		7.87	1.567	1.1032	560	45	135.5	45.59	25.89	0.943	11.5	5.1	19.12	6.1	3.1	0.7
6	N-6		7.82	1.377	0.081	45	12.4	55	46.6	26.36	1.451	0.2	0.1	16.63	5.34	6.67	1.85
7	N-7		8.42	0.638	0.2396	134	8.3	95	15.64	20.33	0.195	3.2	1.5	2.5	0.6	3.98	1.1
8	N-8		8.27	0.135	0.2435	136	3.5	86	64.26	12.61	0.403	3.6	1.6	3.8	0.9	1.88	0.52
9	N-9		7.52	0.281	0.0554	31	6.8	119	25.17	31.44	1.076	6.7	3	5.08	1.63	4	1.12
10	N-10		7.21	1.58	0.4114	230	5.7	51	6.02	40.21	0.996	11.1	5.5	51.25	16.48	4.06	1.12
11	N-11		7.76	0.924	0.3393	218	24.8	100	23.55	26.26	1.991	2.5	1.5	25.75	8.15	4.29	1.14
12	N-12		7.91	0.736	0.2366	132	6	115	1	20.33	0.245	21	9.6	22.8	7.42	3.23	0.89
13	N-13		7.66	0.526	0.1984	111	8	116	52.44	12.61	0.325	16.8	7.7	33.56	9.44	7.77	2.14
14	N-14		7.75	0.88	0.3932	220	24.6	146	10	31.49	0.126	3.5	1.6	9.26	9.97	0.59	10.16
15	N-15		7.89	0.556	0.1576	89	12.6	142	70.67	13.44	1.375	13.1	6	35.46	11.82	6.65	1.84
16	N-16		8.8	0.302	0.5163	298	17.5	61	13.18	19.41	1.244	9.4	4.3	18.57	5.96	22.1	3.87
17	N-17		8.26	0.448	0.5699	358	18.8	114.1	45.4	17.72	0.981	2.9	1.3	19.2	6.02	17.46	3.02
18	N-18		8.5	0.422	0.6234	418	16.9	116.4	22.01	16.31	0.828	10.4	4.8	24.3	7.49	18.91	3.12
19	N-19		8.54	0.389	0.6128	405	27.7	128.8	15	38.09	1.123	2.3	1	28.2	8.13	15.5	4.6
20	N-20		8.38	0.374	0.5924	383	30.5	124.2	6.61	17.41	0.125	3.9	1.8	58.91	18.93	12.3	3.4
21	N-21		7.84	0.363	0.5093	290	24.5	88.7	27.87	23.81	1.144	20.4	9.4	27.88	8.48	18.61	5.81
22	N-22		8.2	1.068	0.2907	162	19.5	150.2	40.11	46.82	0.981	31.1	14.3	20.17	6.48	11.07	2.84
23	N-23		7.68	0.302	0.392	219	15.5	105.1	43.21	38.24	1.404	0.2	0.1	20.48	6.54	15.46	3.49
24	N-24		6.98	0.369	0.3978	222	12.5	93.7	51.28	35.69	0.978	10.3	4.7	26.5	8.52	17.46	4.85
25	N-25		7.08	0.464	0.4754	266	10.6	409.9	45.46	23.74	1.94	8.8	3.9	21.7	6.97	16.35	4.33

*D.W. = Dry Weight

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The physical and chemical inspection of the 25 soil sets from the Narwana area highlights prominent shifts in primary parameters, outlining both fertility blockages and openings for precise management. These insights are gathered in Table- 1 and detailed below, with reasoning tied to baseline BIS/ICAR (IS- 2720) rubrics.

5.1. Soil Reaction and Salinity: pH and Electrical Conductivity

Soil pH serves as a dominant factor controlling nutrient availability, spanning from 6.98 up to 8.8 to indicate neutral to mildly alkaline states. While sets N-10, N-24, and N-25 fit comfortably inside the perfect neutral band ($pH \sim 7$), sets N-2 through N-9 and N-11 through N-23 exhibit moderate alkalinity ($pH > 7.5$). Alkalinity can suppress the availability of vital trace minerals like iron, zinc, and phosphorus via settling and trapping— a widespread challenge across semi-arid zones like Haryana. Extreme pH readings can degrade soil composition and microbial operations as time passes; the recorded span matches regional norms but signals a need for tailored nutrient interventions.

Electrical conductivity (EC) values span from 0.135 to 1.58 dS/m, representing a metric for soil salinity. Soil units N-8, N-9, N-16, N-19 through N-21, N-23, and N-24 are categorized as non-saline; units N-3, N-4, N-7, N-12, and N-13 settle perfectly inside the 0.4 to 0.8 dS/m tier to show minor salinity; conversely, units N-1, N-5, N-6, N-10, N-11, N-14, and N-22 display moderate salinity. Finding mostly standard soil salinity levels stands out as an encouraging outcome of this assessment. Salt accumulation causes element toxicity, moisture stress, and shifts in nutrient equilibria (N, P, K, Ca, Zn, Fe), notably suppressing available phosphorus when it binds with calcium. These minimal EC readings reveal that salt accumulation is not an active barrier to agricultural yields across the assessed locations, allowing management endeavours to centre entirely on nutrient deficits.

5.2. Soil Organic Carbon

Organic Carbon (OC): The volume of soil organic carbon, which is crucial for nutrient cycling, water storage, and soil physical makeup, registered at worryingly depressed thresholds ranging from 0.082% to 1.1032%. Merely 6 sets (N-5, N-16, N-17, N-18, N-19, N-20) neared standard targets, whereas the remaining 19 sets proved deficient based on ICAR thresholds. This widespread loss of organic carbon stems from relentless crop production, low returns of natural matter, and common behaviours like burning crop waste, which burns off carbon elements. The resulting drop in soil organic matter negatively impacts moisture absorption, pore layout, microbial performance, water retention capacity, and nutrient delivery, driving soil compaction and dropping potential yields.

Available Nitrogen (N): Nitrogen levels demonstrated broad scattering, tracking from 31 up to 560 kg/ha. A mere 5 sets (N-16 through N-21) hit the baseline range (240–480 kg/ha), while the prominent majority (19 sets) proved deficient relative to ICAR thresholds, registering as low (< 240 kg/ha). A solitary sample, N-5, exhibited an elevated nitrogen level of 560 kg/ha. This trend points to erratic fertilizer distribution and substantial nitrogen loss through drainage and vaporization. Nitrogen exists as nitrate inside the earth, and adequate levels stimulate growth and pigment generation. Looking at this specific sample analysis, the common low-to-moderate concentrations across most sets indicate a pronounced necessity for refined nitrogen management to bolster yield capacities.

Available Phosphorus (P): The availability of phosphorus spans from 8.5 to 45 kg/ha. According to BIS/ICAR criteria, values below 11 kg/ha represent low levels, 11–22 kg/ha constitute medium levels, and values above 22 kg/ha register as high. Seven sets (N-3, N-5, N-11, N-14, N-19, N-20, N-21) showed elevated numbers, eight sets (N-6, N15, N-16, N-17, N-18, N-22, N-23, N-24) fell into the medium tier, and the remaining samples were thoroughly deficient. This distribution pattern reflects unequal historical fertilizer application. Phosphorus stands as one of the three core N-P-K elements required in substantial volumes for vegetation development. It remains crucial for seed sprouting, root extension, and energy allocation; deficits clearly stunt immature crops, while excess amounts drive locking and chemical runoff. Earth phosphorus ranges of 20–40 pounds per acre (10 to 20 mg/kg) suffice for horticulture and grain farming.

Available Potassium (K): Potassium thresholds spanned from 35 to 409.9 kg/ha. Under BIS/ICAR parameters, a span of 110 to 280 kg/ha counts as standard, values exceeding 280 kg/ha register as high, and values dropping below 110 kg/ha are considered low. Eleven sets (N-1, N-2, N-3, N-6, N-7, N-8, N-10, N-11, N-16, N-21, N-24) registered at low levels (< 110 kg/ha), and sample N-25 showed an elevated concentration of 409.9 kg/ha, while the remaining sets occupied the intermediate tier. Potassium remains vital for triggering enzymes, asset movement, fluid balance, and managing environmental hardships. The potassium deficit recorded across 11 sets can degrade crop health, crop quality, and final yields, leaving plants more vulnerable to dry spells and infections.

Available Sulphur (S): Concentrations of sulphur ranged from 1.0 to 92.35 mg/kg. Adhering to BIS/ICAR rules, a sulphur range of 15–20 mg/kg is standard, values over 100 mg/kg are high, and quantities under 15 mg/kg are

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deficient. Five sets (N-4, N-10, N-12, N-14, N-16) were found deficient (< 15 mg/kg), whereas the remaining samples settled within or above the adequate intermediate band (15–20 mg/kg). A general deficiency of sulphur was not recorded across the region.

5.3. Micronutrient Status

The laboratory screening reveals significant limitations across several trace elements, which frequently operate as yield-limiting elements in intensive grain cultivation systems.

Zinc (Zn): DTPA-extractable zinc quantities ranged from 0.32 to 14.7 mg/kg. Samples N-6 and N-23 demonstrated shortages dipping under the critical threshold of <0.6 mg/kg, whereas the remaining specimens possessed sufficient mandated values (0.6 to 10 mg/kg), and sample N-22 showed a high concentration at 14.3 mg/kg. The benchmark baseline for zinc concentrations in soil and vegetation falls within a span of 0.6 to 1.0 mg/kg for DTPA extraction (Katyal & Ratan, 1993), fluctuating widely based on soil traits and specific crops. Zinc is indispensable for metabolic enzyme operations and internal plant transport. Shortages occur easily in alkaline earth, severely harming crop yield volumes and grain quality. Toxic zinc levels observed in isolated instances might originate from the unbalanced distribution of fertilizers.

Boron (B): The spectrum of boron concentrations spanned from 0.126 to 1.991 mg/kg. Six specific samples (N-4, N7, N-8, N-12, N-13, N-14) dipped below the critical baseline of 0.48 mg/kg, indicating poor supply levels. Boron is fundamental for plant development, cell wall structuring, and seed reproduction; shortages can directly hinder vegetative and reproductive maturation, blooming, fruit development, and ultimate harvest volumes, particularly for dicotyledonous crops.

Manganese (Mn) and Iron (Fe): Manganese measurements ranged from 12.62 to 46.82 mg/kg. According to BIS/ICAR references, the critical range spans 10 to 20 mg/kg, with a maximum allowable ceiling of >100 mg/kg. Eight samples (N-2, N-8, N-13, N-15, N-17, N-18, N-20) registered within critical ranges, while the remaining instances exhibited high volumes up to 46.82 mg/kg. The DTPA-extractable range for iron spanned 0.6 to 18.93 mg/kg. Nine selections (N-1 to N-4, N-6 to N-9, N-16) dropped below the critical baseline, while the remaining samples possessed adequate concentrations. Both of these elements play an essential role in chlorophyll synthesis and photosynthesis. They tend to run low in alkaline soils with high oxygen availability; damp and chilly conditions can induce yellowing (chlorosis) and stifle photosynthetic performance.

Copper (Cu): Copper readouts varied from 0.2 to 10.16 mg/kg. Five samples (N-2, N-3, N-5, N-8, N-12) sat within critical thresholds, whereas the rest displayed elevated amounts. Copper deficiencies increase a plant's vulnerability to infections, weaken its structure, and degrade its stability. Copper's principal function centres on lignin synthesis and driving enzymatic operations.

VI. IMPLICATIONS FOR SUSTAINABLE MANAGEMENT

This comprehensive review reveals an overall soil health profile marred by widespread organic carbon depletion, erratic nitrogen and phosphorus balances, declining potassium and sulphur levels, and budding micronutrient deficits (most notably with boron and iron), alongside generally neutral-to-alkaline pH and non-saline to moderately saline EC measurements. This pattern is typical of broad agricultural zones where synthetic inputs have displaced integrated natural nutrient management systems. The combination of low organic matter and multinutrient disparities highlights the danger that these fertile lands could degrade into low-productivity zones— a localized manifestation of a global issue. Moving away from purely chemical soil fertilization toward natural integrated fertility management represents a vital reversal of this current trend.

The experimental findings strongly support adopting organic land management systems, such as creating green compost, vermicompost, and applying "Divya Amrit" mixtures. These interventions simultaneously remedy several problems: stabilizing soil pH, boosting nutrient cycles and trace element availability, increasing water retention, elevating microbial diversity, and replenishing organic carbon stocks. By sealing the nutrient pathway and reviving biological activity within the ground, these protocols offer a scientifically valid direction that unifies traditional wisdom with sustainable modern agricultural objectives. This strategy can steer regional farming toward natural soil management methods, moving away from destructive, input-heavy habits toward environmental stewardship, thereby ensuring long-term harvest production and ecological balance within the Narwana sub-division of the Jind district and comparable agricultural zones.

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to promote agricultural welfare, preserve biodiversity, and secure environmental safety.

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