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CHEMICAL CHARACTERIZATION AND FERTILITY ASSESSMENT OF SANDY LOAM SOILSIN THE URBANIZING GANGAPUR REGION, AMBIKAPUR

[1*]Laxmi Gupta, [2]Harsh Verma, [3]Hemprakash, [3]Dr. M. K. Maurya

[1]M. Sc. Student, Department of Physics, Rajeev Gandhi Govt. P. G. College, Ambikapur (C.G.), India.

[2]Research Scholar, Department of Physics, Rajeev Gandhi Govt. P. G. College, Ambikapur (C.G.), India.

[3]Assistant Professor, Department of Physics, Rajeev Gandhi Govt. P. G. College, Ambikapur (C.G.), India.

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***Corresponding Author: Laxmi Gupta**

M. Sc. Student, Department of Physics, Rajeev Gandhi Govt. P. G. College, Ambi Kapur (C.G.), India.

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ABSTRACT

Thephysicalandchemicalcharacteristicsofsoildictateitsagriculturalviability,nutrientdynamics,andenvi-ronmentalresilience.Thiscomprehensivestudyinvesti-gatesthesoilprofileof the Gangapurareain Ambikapur,Chhattisgarh—aregiontransitioningfromaruralagrar-ianlandscapeintoarapidsuburbaninstitutionalhub.Fiverepresentativesoilsamplesweresystematicallyex-tracted and analyzed for physical parameters (texture, bulkdensity, structure, waterholdingcapacity) antichemical constituents (pH,electrical conductivity, organic car-bon Macronutrients, and micronutrients) utilizingstan-dardlaboratoryprotocols. Resu ltsclassifytheregionalsoilasawell- drainedsandyloam (Matasi) exhibitingamoderatewaterholdingcapacity (40%) and aslightlyacidicp Hrange (5.4to6.8). Whilethesoilpresentslowelectricalconductivity(averaging0.29dS/m), indicatinganabsenceofsalinitystress, itdemonstratescriticaldefi-cienciesinorganiccarbon (0.36%average)andavailablenitrogen.Conversely,theacidicprofilefacilitatesexcep-tionallyhighavailabilityofmetallicmicronutrientssuchasironandmanganese,alongsidearobustpotassiumbase.Thestudyunderscoresthenecessityforsite-specificnu-trientmanagement,specificallytargetedorganicmanur-ingandzincsupplementation,tobridgeexistingfertilitygaps,counteractpotentialleaching,and sustainregionalagricultureamidstinfrastructuralexpansion.

KEYWORDS*:* Soil Fertility, Sandy Loam, Micronutrients, Ambikapur, Matasi Soil.

INTRODUCTION

Soilisadynamicnaturalresourcethatservesasthefoun-dationforagriculturalproductivityandecological balance.Understandingitsphysicochemicalpropertiesisessentialforevaluatingoverallsoilhealth, diagnosingspecificfer-tilityconstraints, and determiningitsinherentabilitytosupportdiverseplantgrowth [1].Inregionscharacterizedbydiverseclimaticandtopographicalvariations,suchastheSurgujadistrictof Chhattisgarh,site-specificsoilanal-ysisbecomesindispensableforeffectivelandmanagement.

Thestudyarea,Gangapur,issituatedstrategicallyontheoutskirtsofAmbikapur.Itservesasatransitionalzone betweenthetraditionalruralagrarianplainsandrapidsuburbaninstitutionaldevelopment,notably housinga-jorlandmarkslikethe GovernmentMedicalCollege.Ge-ographically locatedatapproximately 23.11°Nlatitudeand83.18°Elongitudeatanelevationof623meters,thisareareceivesanaverageannualrainf allof1,292mm.Thishighprecipitationinfluencestheleachingofbasiccations,contributingdirectlytothelocls oil'sslightlyacidicna-ture.As Gangapurfacesincreasinganthropologicalpres-surefrom both intensive croppingandongoingconstruc-tion,thereisanurgentneedtodocumentbaselinesoilfertility.

Previousbroad-spectrumstudieshaveindicatedthatsoilsintheNorthernHill Region and Mainpat plateausub-zonearepronetocompaction, aeration issues, andnu-trientdepletion [2].

However, micro-leveldataspecificallytargetingtherapidlyevolving Gangapurregionremainslimited. Thisresearchaimstobridgethatgapbycon-ductingarigorousphysicochemicalcharacterizationofthe local soil, ultimatelyproposingsustainablemanagementstrategiestailoredtoitsuniqueprofile.

LITERATURE REVIEW

Theassessmentofsoilhealthreliesheavilyonaconver-genceofphysicalandchemicalanalyses.Physicalat-tributessuchastexture,bulkdensity,andporositydi-rectlyinfluencewaterretention,rootpenetration,andmi-crobialhabitats[1].StudiesintropicalregionslikeChhat-tisgarhrevealthattexturesvarywidely, stronglyinflu-encingcropresponseandwateravailability.Heavycom-pactionoftenrestrictssoilaeration, effectivelysuffocatingrootzones[6].

Chemically,pHisacriticaldeterminantofnutrientsol-ubility.Thepreferredrangeformostcropsis6. 0to7.5;acidicsoils(pH<6.0)oftenlimitphosphorusandmolyb-denumavailabilitywhileincreasingthesolubilityofironandmanganesetopotentiallytoxiclevels[9]. Electricalconductivity(EC)actsasanindicatorofsalinitystress.ElevatedECcausesosmoticstress,thoughth esoilsoftheAmbikapurregiongenerallyremainsafelybelowthe1.0 dS/mthreshold[4].Organiccarbon,derivedfromdecom-posedmatter,isvitalformaintainingfertilityandstr -ture.Loworganiccarbon,prevalentinmanyIndiansoils,restrictsmicrobialbiomassandnutrientcycling[8]

.Thedelicatebalanceofmicronutrients(Zn, Cu,Fe,Mn,B) governs enzymatic functionsandplantmetabolism;tar-getedsupplementationisoftenrequiredtocorrectlocal-izeddeficiencies[3].

Materials And Methods

1.1 Study Area Description

TheinvestigationwascarriedoutinGangapur, Ambika-purblock of Surgujadistrict, Chhattisgarh. The climateissub-tropical, markedbyhotsummers (reachingupto41˚Cin May) and cool winters (dropping to 8 ˚C).

Theregionisborderedbydensedeciduousforestsandthe GungataNaladrainagesystem,influencingthelocalalluvialandsedentarysoildeposits.

1.2 Sampling Tools and Preparation

Fiverepresentativesamplinglocationswereidentifiedacrossthe153.33-hectarestudyzonetocapturespatialvariability.Soilsampleswereextractedfromtheactiverootzone(0–15cmdepth).

Thefollowingtoolswereuti-lized:

- Spade/Khurpi&SoilAuger: Fordiggingandextract-ingaccuratedepthprofiles.
- SoilCoreSampler:Tocollectintactcoresforbulkdensityassessment.
- PortableGPS:Torecordprecisegeographiccoordi-nates.
- 2mm MeshSieve:Forfilteringcoarsematerialsandplantdebris.

Topreventcross-contamination,sampleswerestoredinclean,labeledpolythenebags.Priortoanalysis, thesoilwasair-driedinashaded, dust- freeenvironmentfor72hours, gentlycrushedusingawoodenmallet, andpassedthroughthe2mmsievetoachievehomogeneity.

Figure1:Polythenebagsutilizedforcollectingandstoringsoilsamplesfromthefieldtopreventmoisturelossandcross-contamination.

1.3 Analytical Techniques

PhysicalevaluationincludedtexturedeterminationviatheBouyoucosHydrometermethodandbulkdensityesti ma-tionusingtheCoremethod.Chemicalanalyseswereper-formedusingstandardizedlaboratoryprotocols:

- pHandEC:Measuredina1:2.5soil-watersuspensionusingdigitalmeters.
- OrganicCarbon(OC):EstimatedviatheWalkleyandBlackwetoxidationmethod.
- AvailableNitrogen(N):Determined by theAlkalinePermanganatemethod(Subbiah& Asija,1956).
- AvailablePhosphorus(P)&Potassium(K):PwasmeasuredusingOlsen'smethod;Kwasextractedus-ingneutral ammonium acetate and quantifiedviaflamephotometry.
- Micronutrients&Sulphur:Analyzedusingatomicab-sorptionspectrophotometryandstandard extractionmethods.

RESULTS

1.4 PhysicalProperties

ThephysicalanalysisconfirmedthattheGangapursoilpossessesapredominantlysandyloamtexture,locallyr e-ferredtoas'Matasi'soil.Theparticlesizedistributionaveraged70%sand,20%silt,and10%clay.

Thisgranulartosub-angularblockystructureresultsinabulkdensityofapproximately1.5g/cm^3.
Thewaterholdingcapacity (WHC)wasrecordedat40%.

1.5 Chemical Properties

ThechemicalreactionofthesoilvariedfromstronglytoslightlyacidiC,withpHvaluesrangingfrom5.4to 6.8.Electricalconductivityremainedconsistentlylowacrossallsamples(0.08to0.60dS/m).Organiccarbonl evelsfluctuatedbetween0.24%and0.44%.

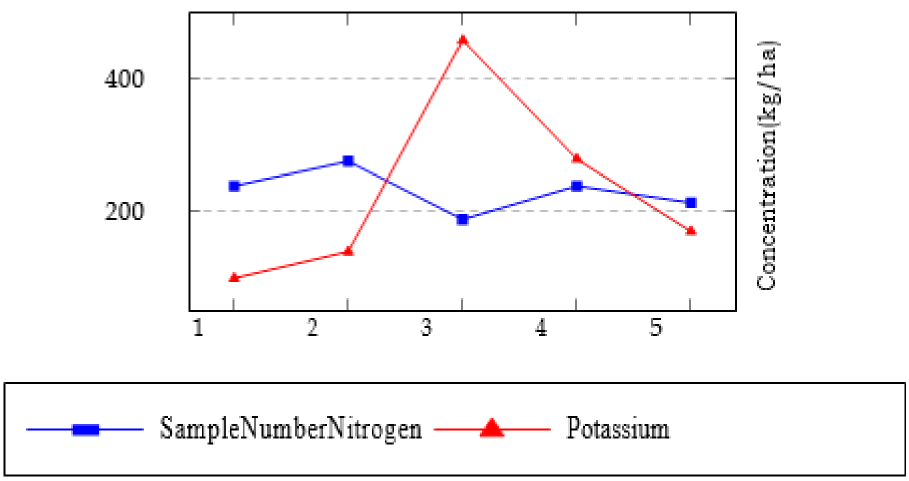

Figure2: DistributionofavailableNitrogenandPotas-siumacrossthefivesoilsamples.

AsillustratedinFigure2,availablenitrogenlevels(188.16to275.96kg/ha)remaingenerallylow.Sampl e3exhibitedananomalouslyhighpotassiumconcentration(459.2kg/ha).

1.6 Micronutrient and Sulphur Profiling

Figure3presentsacomprehensivelogarithmicmasterpro-fileofthestudiedvariables.Iron(14.3–24.8ppm)andmanganese(11.4–31.4ppm)arepresentinhighamounts.Sulphurwasalsorecordedathighlevels (mean20.9ppm).Zincconcentrationsaveraged0.77ppm,andBoronre-mainedbetween0.6and0.7ppm.

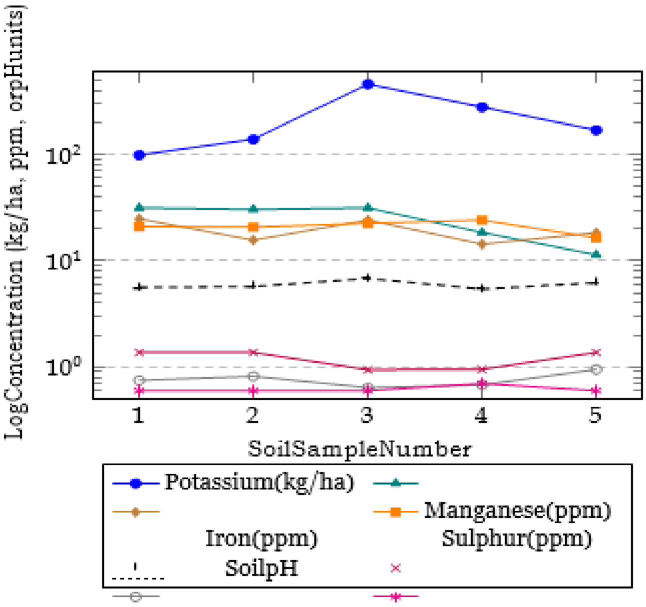

Figure3: Final Master Profile: Nutrient Trendsand Soilp Hplottedonalogarithmicscale.

DISCUSSION

1.7 Evaluation of Soil Health Parameters

ThephysicalfoundationoftheGangapursoil(bulkden-sity1.5g/cm^3,40%WHC) fallswellwithintheacceptablerangeforagriculturalsoils,ensuringoptimalrootpenetra-tionandaeration. Whilethehighsandcontentminimizestheriskofwaterlogging,itsimultaneouslycreatesaleachyenvironment,m akingthesoilsensitivetomoisturestressduringprolongeddryspells.

Table1benchmarkstheobservedvaluesagainststan-dardcriticallimits. Theslightlyacidicnatureregulatesthenutrientdynamicsheavily.Thelowelectricalcon-ductivityensuresanabsenceofsalinitystress.However,organiccarbonandavailablenitrogenstrict lyfallinthedeficientcategory. Thisdeficiencydirectlyimpactsthesoil’sbufferingcapacity,moistureretention,andoverallmicrobialhealt h,requiringimmediatesupplementation.

Table1: Comparison of Gangapur Soil Parameters with Standard Critical Limits

Parameter	Observed Mean	IdealRange/Threshold	Status
pH	6.1	6.0–7.5	SlightlyAcidic
EC(dS/m)	0.29	<1.0	Normal
OrganicCarbon (%)	0.36	>0.50	Low
AvailableN(kg/ha)	230.79	280−560	Low
Available(kg/ha)	229.02	110−280	High
Sulphur(ppm)	20.94	>10.0	High
Iron(ppm)	19.42	>4.5	VeryHigh
Manganese(ppm)	24.60	>2.0	VeryHigh
Zinc(ppm)	0.77	>0.6	Marginal
Boron(ppm)	0.62	>0.5	Sufficient

Therobustpotassiumbaseobservedinthestudyareaishighlybeneficialforstressresistance,cellwallstrength-ening,andenzymeactivationinpulseandtubercrops.Conversely,metalssuchasironandmanganesearehighlysolubleatlowerpHlevels,reflectedintheelevatedcon-centrations. Zincconcentrationshoverdangerouslyclosetothedeficiencymark,andBoronremainssufficientbutrelativelylow,necessitatingcarefulmonitoringtopreventreproductivefailureinfloweringcrops. fruittreeslikelitchi.

5.2 Crop Suitability

Basedonthesynergisticeffectsoftheobservedphysicalandchemicalproperties,theGangapursoilishighlysuit-ablefor:

- Cereals(PaddyandMaize):BenefittingfromhighFe/Mnlevels andexcellentaeration.
- Oilseeds(MustardandNiger):Supportedbysuffi-cientSulphurandaslightlyacidicpH.
- PulsesandHorticulture:Thehighpotassiumbaseandwell-drainedgranularstructureeasilysupportrootpenetrationfortubercropslikepotatoesand

Conclusion and Future Scope

ThesoiloftheGangapurregioninAmbikapurischarac-terizedasawell-drained, structurallysoundsandyloamwithaslightlyacidicprofile. Whilephysicalparametersheavilyfavorrootdevelopmentandaeration,preventingwaterlogging, thechemicalanalysisrevealsspecificnutri-entimbalances.Thesoilisexceptionallyrichinpotas-sium,iron,manganese, and Sulphur, establishing's ongmin era base. Nevertheless, the inherently low organiccarbonandavailablenitrogen, coupledwithmarginalzinclevelsandlowwaterretentioncapacity, presentclearbarrierstoachievingmaximumyieldpotential. Itisrecommendedthatlocalfarmersintegrateorganiccompostsorfarmyardmanure(FYM)to enhancemoistureretentionandapplytargetedzincsulfateamendments.

FutureScope:FutureresearchshouldfocusonSite-Specific Nutrient Management (SSNM) and precisionmappingofmarginalelementslikeZincandBoron.In-tegratingagroforestryandregenerative farmingpracticescan sequester carbon, improve thecurrentlydeficient or- ganicmatterpool, and stabilized ysicalstructure againsterosion.Bytransitioningtoprecision-basedfer-tilization, theregioncanoptimizeitsfertilityandensuresustainableproductivityamidstrapidsuburbanization.

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