Chapter 5

CONCLUSION

This chapter contains the conclusions of our research work findings.

5.1 Soil Quality

A comprehensive analytical and statistical analysis of distribution of various soil quality parameters in both inside and outside the tea gardens of Darrang district, Assam has been presented. An important question which must be addressed, when we are concerned with the potential environmental impact of particular soil components, is how we relate the results of our analytical procedures to the environmental context in which we find the soil (Bavinck *et al.*, 1988). Due to the availability of information, the focus of this study has been with respect to the chemical analysis of soils, and the presentation and interpretation of the results of soil chemical analysis. As there is no universal soil test capable of assessing the ability of the soil to store and gradually release nutrients, the sufficiency, or otherwise, of each nutrient will need to be assessed individually. Soil quality involves placing a value upon soil in relation to a specific function or purpose.

In this study, bulk density as indicator of compaction and potential for leaching, productivity, and erosivity, soil organic matter for defining soil fertility and stability, pH for defining biological and chemical activity thresholds, electrical conductivity, SO_4^{2-}, Cl^- as indicator of total concentration of soluble salts, Available N, P, and K as productivity and environment quality indicators, Ca, Mg, Fe, Zn, Mn, Pb, Cu to assess the metal loads are studied separately for getting an overall picture of the soil quality in the area. Physical and chemical properties of soil are measured during the study for ensuring that soil function is maintained, not only for the current land use, but also for potential future uses. Different metals like Fe, Mn, Zn, Cu, Pb, etc.in the soil are found to be high as prescribed by different standards. The intensive and particularly overuse of fertilizers and pesticides were the major causes of the accumulation and contamination of heavy metal elements in the agricultural lands in the region of investigation. Hence, judicious use of fertilizers and pesticides may be one of the best preventive measures in maintaining soil quality.

In the range of soils examined during the study, those under the tea gardens, usually have lower pH as compared to the nearby paddy fields. Extreme acidification of soils in the study area results in poorly structured or hard-setting top soils, reduction in the availability of nutrients (calcium, magnesium and phosphorus) and also increase in toxic levels of aluminium, manganese, iron and sulphur. With a slight inclination of pH towards higher side outside the tea gardens, the availability of soil nutrients like nitrogen, phosphorous, calcium and magnesium also increases. Soil carbon level is found to be marginally high in the area as compared to the other attributes. The analysis of the soil samples of paddy fields around the plantation area of tea gardens of Darrang district reveal that the soil health is not in accordance with the fertility rating chart given by ICAR (2005).

We have also calculated the confidence limit for each soil quality parameter within which the unknown value of the parameter is expected to lie. In the following Table 5.1 the mean soil quality parameters of the study area are compared with their critical limits as per chemical ranking chart. Correlations among the studied parameters are presented in Tables 5.2 I(a) and I(b). Pearson's correlation coefficient measures the closeness of the relationship between chosen independent and dependent variables.

Since the directions of association of the measured variables are unknown in advance, two tailed test of significance was carried out and presented in Tables 5.2 I(a) and I(b). It is observed that some of the soil quality parameters correlation is significant at the 0.01 and 0.05 level.

The quality of soils in the tea garden belt of Darrang district, Assam has declined significantly due to excessive use of agro-chemicals and poor management practices. The long-term exploitation of soil under the tea gardens in Darrang district, Assam has led to impoverishment of soil fertility and stabilization of yields, despite increasing application of external inputs such as fertilizers and pesticides. Statistical observations show all the parameters exhibit an asymmetric distribution with a long tail either on the right or left side of the mean in the study area. Wide data range, high standard deviation, differences between mean, mode and median, significant skewness and kurtosis value indicate that the distribution of the studied parameters in the study area is widely off normal. Thus, the inherent fertility of soils in and around the tea gardens of Darrang district, Assam is low because of either low or high nutrient status in soils. Soil nutrient imbalance is the key issue that needs to be taken up in the area. This study reinforced the extensive nature of degradation of soil in the area under study. It is, therefore, important that we value and conserve our soils so that they will continue to be useful in the future. Globally, and regionally, there is an urgency to develop guidelines for protection and monitoring of the quality of soil and land resources.

Table 5.1: Soil quality parameters with rating

Sl. No.	Soil Quality Parameters	Inside	Outside	Rating		
		Mean	Mean	Low	Medium	High
1	Soil pH (Units)	4.67	5.13	< 6.0 [1]Acidic	6.0-8.5 Normal	>9.0 Alkaline
2	Electrical Conductance (µmhos/cm)	1403	709		< 1000 [1]Normal	1000-2000 Critical
				<400 [2]Normal	400-800 Fairly safe	810-1200 Critical
3	(%) Carbon	1.987	1.703	[1]<0.5	0.5-0.75	>0.75
4	Available Phosphorous (Kg/acre)	51.90	61.94	[1]<25	25-62	>62
				<34 [2]Kg/ha	34-68	>68
5	Available Potassium (Kg/acre)	101.79	100.17	[1]<272	272-690	>690
6	Available Nitrogen (Kg/ha)	571.43	441.67	[1]<280	280-560	>560
7	Iron (mg/L)	748.84	884.63	<3.0 [2] (mg/kg)	<5.0	>5.0
8	Manganese (mg/kg)	119.98	169.43	<2.00 [2] (mg/Kg)	<1.0	>1.0
9.	Pb(mg/kg)	19.75	23.34			
10	Sulphate-Sulphur (mg/kg)	9.739	12.092	[3]0-10	10-15	15-20
11	Calcium (meq/100 gm)	1.73	1.94	[2] <4.5	-	-
12	Magnesium (meq/100 gm)	0.41	0.45	-	-	-
13	Zinc (mg/kg)	50.33	29.79	[4]<0.3	0.3-2.3	>2.3
14	Bulk density (g/cm3)	1.097	1.027	-	-	-
15.	Cupper(mg/kg)	20.97	17.22	-	-	-

[1]ICAR, 2005, Hand Book of Agriculture, 3rd Edition, Indian Council of Agricultural Research, New Delhi, P. 71

[2] In: Soil Analysis Hand Book of Reference Methods, Soil and Plant Analysis Council, CRC Press, 2004.

[3]Takkar, P.N. (1988) Sulphur states of Indian soils pp S 1/2-1 to 31. In TSI-FAI Sulphur in Indian Agriculture, Sulphur Institute, Washington D.C. and FAI, New Delhi.

[4]Baruah, T.C.C & Borthakur, H.P, 1997, In: A Text Book of Soil Chemical Analysis, Vikash Publishing, New Delhi.

Table 5.2 : Correlation table for soil parameters

I (a) Pearson's Two-tailed Correlations among Soil quality parameters inside the teagardens

		pH	P_b	%C	N	P	K	Zn	Cu	Mn	Fe	Pb	Ca	Mg	SO_4^{2-}	Cl⁻
pH	correl	1.000														
	Sig. (2-tailed)	.														
P_b	correl	0.119	1.000													
	Sig. (2-tailed)	0.638	.													
%C	correl	0.345	0.431	1.000												
	Sig. (2-tailed)	0.161	0.074	.												
N	correl	0.520*	0.320	0.732**	1.000											
	Sig. (2-tailed)	0.027	0.196	0.001	.											
P	correl	0.230	0.398	-0.067	0.297	1.000										
	Sig. (2-tailed)	0.360	0.102	0.792	0.231	.										
K	correl	0.246	0.502*	0.113	0.268	0.480*	1.000									
	Sig. (2-tailed)	0.324	0.034	0.655	0.283	0.044	.									
Zn	correl	-0.351	0.163	0.174	-0.124	-0.423	-0.188	1.000								
	Sig. (2-tailed)	0.153	0.517	0.490	0.625	0.080	0.454	.								
Cu	correl	-0.476	-0.276	-0.356	-0.120	-0.074	-0.095	0.297	1.000							
	Sig. (2-tailed)	0.053	0.283	0.161	0.647	0.777	0.716	0.246	.							
Mn	correl	0.528*	0.352	0.483*	0.678**	0.117	0.067	0.205	-0.272	1.000						
	Sig. (2-tailed)	0.024	0.152	0.042	0.002	0.644	0.792	0.416	0.291	.						
Fe	correl	0.493*	0.131	0.161	0.571*	0.139	0.026	0.062	0.182	0.827**	1.000					
	Sig. (2-tailed)	0.038	0.605	0.522	0.013	0.583	0.918	0.808	0.485	0.000	.					
Pb	correl	-0.238	0.370	0.085	-0.273	-0.181	-0.205	0.672**	-0.305	0.114	-0.160	1.000				
	Sig. (2-tailed)	0.343	0.131	0.739	0.274	0.473	0.414	0.002	0.234	0.651	0.527	.				
Ca	correl	0.106	-0.118	0.082	0.097	-0.314	0.037	-0.289	-0.043	-0.018	-0.032	-0.305	1.000			
	Sig. (2-tailed)	0.675	0.642	0.746	0.703	0.204	0.884	0.245	0.869	0.944	0.901	0.218	.			
Mg	CORREL	-0.044	-0.216	0.021	0.000	-0.152	-0.126	-0.223	0.103	-0.025	-0.067	-0.294	0.549*	1.000		
	Sig. (2-tailed)	0.864	0.388	0.933	0.999	0.548	0.619	0.374	0.695	0.922	0.792	0.236	0.018	.		
SO_4^{2-}	correl	-0.534*	0.052	-0.270	-0.123	0.361	-0.098	0.023	0.127	-0.196	-0.207	0.257	-0.182	-0.110	1.000	
	Sig. (2-tailed)	0.022	0.839	0.278	0.625	0.141	0.698	0.928	0.628	0.435	0.409	0.304	0.470	0.664	.	
Cl⁻	correl	-0.306	0.744**	0.295	0.050	0.317	0.177	0.357	-0.094	0.060	-0.223	0.579*	-0.331	-0.283	0.444	1.000
	.	0.217	0.000	0.234	0.844	0.200	0.482	0.146	0.720	0.812	0.375	0.012	0.180	0.256	0.065	.

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

I (b) Pearson's Two-tailed Correlations among Soil quality parameters outside the teagardens

		pH	P_h	%C	N	P	K	Zn	Cu	Mn	Fe	Pb	Ca	Mg	SO_4^{2-}
pH	CORREL	1.000													
	Sig. (2-tailed)	.													
P_h	CORREL	0.160	1.000												
	Sig. (2-tailed)	0.400	.												
%C	CORREL	-0.006	0.211	1.000											
	Sig. (2-tailed)	0.975	0.263	.											
N	CORREL	0.059	0.144	0.662**	1.000										
	Sig. (2-tailed)	0.756	0.449	0.000	.										
P	CORREL	0.157	0.272	0.109	0.294	1.000									
	Sig. (2-tailed)	0.408	0.145	0.565	0.115	.									
K	CORREL	0.112	0.351	0.223	0.296	0.464**	1.000								
	Sig. (2-tailed)	0.555	0.057	0.235	0.112	0.010	.								
Zn	CORREL	-0.389*	0.135	0.259	0.012	-0.392*	-0.160	1.000							
	Sig. (2-tailed)	0.034	0.476	0.167	0.949	0.032	0.399	.							
Cu	CORREL	-0.446*	-0.215	-0.249	0.053	-0.018	-0.076	0.281	1.000						
	Sig. (2-tailed)	0.015	0.262	0.193	0.785	0.927	0.694	0.140	.						
Mn	CORREL	0.441*	0.214	0.294	0.194	0.195	0.032	0.047	-0.208	1.000					
	Sig. (2-tailed)	0.015	0.257	0.115	0.305	0.301	0.865	0.805	0.278	.					
Fe	CORREL	0.493**	0.061	0.059	0.346	0.207	0.034	-0.080	0.136	0.756**	1.000				
	Sig. (2-tailed)	0.006	0.748	0.755	0.061	0.273	0.858	0.674	0.482	0.000	.				
Pb	CORREL	-0.018	0.006	-0.104	-0.285	-0.222	-0.246	0.349	-0.266	0.124	-0.021	1.000			
	Sig. (2-tailed)	0.923	0.976	0.585	0.127	0.239	0.190	0.059	0.163	0.513	0.913	.			
Ca	CORREL	0.147	0.085	-0.016	-0.113	-0.213	0.042	-0.310	-0.128	0.108	0.016	-0.193	1.000		
	Sig. (2-tailed)	0.437	0.653	0.935	0.552	0.259	0.826	0.096	0.509	0.572	0.934	0.307	.		
Mg	CORREL	0.042	-0.038	0.041	0.002	-0.025	-0.066	-0.203	0.075	0.041	-0.018	-0.270	0.552**	1.000	
	Sig. (2-tailed)	0.824	0.841	0.829	0.993	0.895	0.728	0.282	0.699	0.829	0.925	0.149	0.002	.	
SO_4^{2-}	CORREL	-0.017	0.343	-0.224	-0.279	0.255	0.024	-0.094	-0.031	-0.033	-0.092	-0.175	0.206	0.103	1.000
	Sig. (2-tailed)	0.928	0.063	0.234	0.136	0.174	0.901	0.623	0.872	0.864	0.629	0.355	0.274	0.589	.
Cl^-	CORREL	0.076	0.387*	0.017	-0.124	0.176	0.078	0.166	-0.139	0.015	-0.138	0.417*	-0.264	-0.246	0.276
	Sig. (2-tailed)	0.690	0.034	0.930	0.513	0.353	0.681	0.381	0.473	0.938	0.466	0.022	0.158	0.190	0.140

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

5.2 Water Quality

A comprehensive analytical and statistical analysis of distribution of pH, EC, Cl^-, SO_4^{2-}, exchangeable Ca and Mg, Na, K, Zn, Pb, Cd, Mn, Cu, As & Fe. in drinking water of tea garden belt of Darrang district, Assam has been presented in this study. The water sources, selected for this study, have been in use for a long time for meeting drinking water needs and other domestic purposes. No detailed analysis of the water quality of these sources with respect to the presently investigated parameters had been undertaken before. The focus of the study is on the tea garden belt rather than urban areas, due to the particular difficulties associated with applying mitigation measures in scattered tea garden communities. The present study has shown that naturally occurring phosphate, arsenic and iron in water sources are more widespread in the study area than is generally recognized and that, with continuous testing, more contaminated aquifers are bound to be identified. The observed variations in quality of water samples in the study area suggest that the area is sensitive to contamination as excessive rainfall or over-irrigation can cause downward movement of water through the soil profile. Chemicals which do not bind strongly to soil particles can be carried with the downward moving water and eventually can be leached to the groundwater thereby polluting the water sources.

The supply of pure and safe water is inadequate in the study area and was almost non-existent in the rural areas of Darrang district, Assam. People use water for drinking mostly from tubewells, dugwells, rainwells and ponds. Good source of drinking water is essential for good health. Although some people have their own water supply systems, they are not completely safe with respect to all water quality parameters. In our study area, it is found that tube well, ring well and dugwell are the main source of drinking water of the households. Some of the dug-wells from where people use to drink are unprotected. It was also found that some households drink water from river. The concentration of phosphate, iron, cadmium and lead in the water sources of the area is beyond the national and international permissible limits for drinking water. Though this study was not originally designed to address the issue of metal mobilisation in the sources of waters in the tea garden area of Darrang district, present observations can be used to comment qualitatively on their mobilisation in the groundwaters of the area. Contamination of drinking-water with iron, cadmium and lead further illustrates the difficulties of community-based interventions. It may be seen from our results that most of the tubewell water samples of the study area were found unsafe with regard to the studied parameters.

Statistical observations show all the parameters under investigation exhibit an asymmetric distribution with a long asymmetric tail either on the right or left of the median. The width of the third quartile was consistently found to be more than the second quartile for each parameter. Differences among mean, mode and median, significant skewness and kurtosis value indicate that the distribution of various water quality parameters in the study area is widely off normal. Sporadic occurrence of all the water quality parameters has been observed in the area. Reliability analysis with reference to Pearson's correlation coefficient shows that some of the water quality parameters are negatively correlated and hence is significant at the 0.05 level. t-test and ANOVA analysis also suggests that some water quality parameters in the area is significant. The chemical water quality parameters along with Guideline Chart and the correlation among the studied parameters are summarized in Tables 5.3, 5.4 , 5.5 II(a), II(b), III(a), III(b) and 5.6 IV(a), IV(b), V(a), V(b) given below.

Thus, the inherent quality of drinking waters in the study area is low and not encouraging due to unsymmetrical distribution of various water quality parameters. As a result scarcity as well as chemical contamination of water affects a large number of people. Moreover, outbreak of waterborne diseases such as dysentery, jaundice, skin diseases etc. are very common among the people of the study area. Malaria is another common disease which affects the people in the tea garden belt. The problem accentuated much by the absence of proper medical facilities to fight the menace of unsafe and contaminated water. If the people continue to use contaminated water, many will lose their health or die within a few decades. Those who will survive are in danger of carrying genetic and other diseases to the future generation. Unfortunately, the people in Darrang district are still unaware of water contamination and its hazardous effects. The efforts are much less than needed to mitigate the crisis. Hence, the immediate involvement of the research community is needed to combat the slow-onset disaster and save the poor people. For a rural and backward district like Darrang of Assam where the majority of the people live below the poverty line, the provision of safe drinking water is one of the prior conditions for overall social development. As water-borne epidemics and health hazards in the aquatic environment are mainly due to improper management of water resources, so proper management of water resources in the area is the need of the hour. Follow-up monitoring and education are integral to sustaining the impact of the first intervention and to safeguarding the population's health. The role of the health sector for supplying better quality water among the public to maximize health gains should be advocated in the area. A key component of this role is the regular surveillance of water supplies in order to assess progress with meeting targets consistent with stated public health goals and to identify priority areas for intervention.

Table 5.3: Analytical data of water inside tea garden with rating chart

Sl No.	Parameters	Mean Values		International Standards			
		Pre Monsoon	Post Monsoon	W.H.O	I. S. I	USPHS	European Standard
1.	Turbidity(N.T.U)	0.585	0.971	5NTU	5	-	
2	pH (Units)	6.67	6.81	6.5-8.5	6.5-8.5	6.0-8.5	5.0-9.0
3	Electrical conductanc (mmhos/cm)	1.78	1.64	-	0.75	0.3	0.4
4	TS (mg/L)	548	196	-	-	-	-
5	TSS (mg/L)	32	8	-	-	5.0	-
6	TDS (mg/L)	550	260	1000	500	500	500
7	DO (mg/L)	4.93	4.54	-			
8	Alkalinity (mg/L)	42.44	47.54	-	-	-	-
9	Hardness (mg/L)	27.86	32.36	250	-	250	-
10	Ca (mg/L)	8.87	9.83	100	75	100	100
11	Mg (mg/L)	2.04	1.43	150	30	30	-
12	Fe (mg/L)	1.15	0.81	0.3	1.0	0.3	-
13	Chloride (mg/L)	35.60	45.37	250	250	250	200
14	Sulphate (mg/L)	3.45	6.50	250	150	250	250
15	Nitrate (mg/L)	0.73	0.68	50	45	10	-
16	Phosphate (mg/L)	0.53	0.52	-		0.1	
17	Flouride	0.69	0.54	1.5 mg/l	1.0	1.5	1.0
18	Lead (mg/L)	0.124	0.097	0.01	0.05	0.015	0.1
19	Cadmium (mg/L)	0.120	0.109	0.003		0.003	0.01
20	Copper(mg/L)	0.068	0.068	2.00	2.00	2.00	
21	Manganese (mg/L)	0.031	0.024	0.05		0.05	0.05
22	Arsenic (ppb)	2.729	1.526	50	10	50	50
23	Zinc (mg/L)	0.243	0.197	5.0		5.0	
24	Na (mg/L)	22.5	28.8	200		200	
25	K(mg/L)	4.1	5.1	-		-	

Table 5.4: Analytical data of water outside tea garden with rating chart

-.	Parameters	Mean Values		International Standards			
		Pre Monsoon	Post Monsoon	W.H.O	I. S. I	USPHS	European Standard
	Turbidity(N.T.U)	0.621	1.235	5	5	-	
	pH (Units)	6.46	6.51	6.5-8.5	6.5-8.5	6.0-8.5	5.0-9.0
	Electrical conductance (mmhos/cm)	1.69	1.64	-	0.75	0.3	0.4
	TS (mg/L)	548	196	-	-	-	-
	TSS (mg/L)	32	8	-	-	5.0	-
	TDS (mg/L)	550	260	1000	500	500	500
	DO (mg/L)	5.38	4.85	-	-		
	Alkalinity (mg/L)	45.75	57.30	-	-	-	-
	Hardness (mg/L)	33.21	36.86	250	-	250	-
0	Ca (mg/L)	11.89	14.18	100	75	100	100
	Mg (mg/L)	2.61	2.31	150	30	30	-
2	Fe (mg/L)	1.28	1.59	0.3	1.0	0.3	-
3	Chloride (mg/L)	23.33	31.54	250	250	250	200
4	Sulphate (mg/L)	7.87	10.21	250	150	250	250
	Nitrate (mg/L)	0.52	0.44	50	45	10	-
5	Phosphate (mg/L)	0.46	0.34	-	-	0.1	
7	Flouride(mg/L)	0.61	0.49	1.5 mg/l	1.0	1.5	1.0
8	Lead (mg/L)	0.169	0.121	0.01	0.05	0.015	0.1
9	Cadmium (mg/L)	0.132	0.102	0.003	-	0.003	0.01
0	Copper(mg/L)	0.064	0.033	2.00	2.00	2.00	
1	Manganese (mg/L)	1.213	1.097	0.05	-	0.05	0.05
2	Arsenic (ppb)	3.056	1.879	50	50	50	50
3	Zinc (mg/L)	0.554	0.443	5.0	-	5.0	
4	Na (mg/L)	24.5	30.9	200	-	200	
5	K(mg/L)	3.9	6.8	-	-	-	

Table 5.5: Correlation table for water quality parameters inside the tea gardens

II (a) Pearson's Two-tailed Correlations among Water quality parameters inside the teagardens in the premonsoon season

		HARDNESS	TS	TSS	TDS	Alkalinity	EC	Cl^-	SO_4^{2-}	DO	NO_3^{-1}	PO_4^{-3}	F-	T
HARDNESS	Pearson Correlation	1												
	Sig (2-tailed)	.												
TS	Pearson Correlation	-0.153	1											
	Sig (2-tailed)	0.601	.											
TSS	Pearson Correlation	-0.321	0.455	1										
	Sig (2-tailed)	0.263	0.102	.										
TDS	Pearson Correlation	-0.152	0.999**	0.429	1									
	Sig. (2-tailed)	0.604	0.000	0.126	.									
Alkalinit	Pearson Correlation	0.051	0.369	-0.099	0.382	1								
y	Sig (2-tailed)	0.862	0.195	0.736	0.178	.								
EC	Pearson Correlation	0.224	-0.383	-0.226	-0.375	-0.158	1							
	Sig (2-tailed)	0.442	0.176	0.436	0.186	0.589	.							
Cl^-	Pearson Correlation	0.171	0.307	0.379	0.300	-0.060	-0.185	1.						
	Sig (2-tailed)	0.559	0.286	0.181	0.298	0.840	0.527	.						
SO_4^{2-}	Pearson Correlation	-0.031	0.815**	0.161	0.827*	0.398	-0.345	0.077	1					
	Sig (2-tailed)	0.916	0.000	0.582	0.000	0.159	0.227	0.794	.					
DO	Pearson Correlation	0.528	0.087	-0.393	0.094	0.104	-0.147	0.107	0.418	1.				
	Sig (2-tailed)	0.052	0.766	0.164	0.750	0.724	0.615	0.716	0.137	.				
NO_3^{-1}	Pearson Correlation	0.171	0.411	0.046	0.407	0.482	-0.514	-0.101	0.522	0.561(*)	1			
	Sig. (2-tailed)	0.559	0.144	0.876	0.149	0.081	0.060	0.731	0.056	0.037	.			
PO_4^{-3}	Pearson Correlation	0.204	0.505	-0.007	0.507	0.114	0.134	0.272	0.343	0.258	0.233	1		
	Sig. (2-tailed)	0.484	0.066	0.981	0.065	0.698	0.648	0.347	0.230	0.373	0.422	.		
F-	Pearson Correlation	0.050	-0.258	-0.252	-0.246	0.321	0.073	-0.132	-0.122	0.145	0.320	0.231	1	
	Sig. (2-tailed)	0.864	0.373	0.385	0.396	0.263	0.805	0.654	0.679	0.621	0.265	0.426	.	
Turbidity		-0.205	0.341	0.545*	0.322	-0.087	-	-0.040	0.073	-0.290	0.384	-0.072	-	
		0.481	0.233	0.044	0.262	0.766	0.013	0.891	0.804	0.314	0.175	0.806	0.628	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

II(b) Pearson's Two-tailed Correlations among Water quality parameters inside the teagardens in the premonsoon season

		pH	Ca	Mg	Fe	Cu	Mn	As	Pb	Cd	Zn	Na	K
pH	Pearson Correlation	1											
	Sig (2-tailed)	.											
Ca	Pearson Correlation	0.264	1										
	Sig (2-tailed)	0.362	.										
Mg	Pearson Correlation	-0.140	-0.046	1									
	Sig (2-tailed)	0.633	0.875	.									
Fe	Pearson Correlation	-0.014	-0.373	-0.329	1								
	Sig (2-tailed)	0.962	0.189	0.251	.								
Cu	Pearson Correlation	0.514	0.197	-.552(*)	0.028	1							
	Sig (2-tailed)	0.060	0.499	0.041	0.923	.							
Mn	Pearson Correlation	-0.036	0.100	0.196	-0.001	-0.219	1						
	Sig (2-tailed)	0.902	0.735	0.503	0.998	0.452	.						
As	Pearson Correlation	-0.271	-0.412	-0.279	.637(*)	-0.150	0.104	1					
	Sig (2-tailed)	0.348	0.144	0.335	0.014	0.609	0.725	.					
Pb	Pearson Correlation	-0.167	0.162	0.457	-0.383	-0.388	.596(*)	-0.145	1				
	Sig. (2-tailed)	0.569	0.580	0.101	0.177	0.170	0.024	0.620	.				
Cd	Pearson Correlation	0.394	-0.270	-0.304	0.094	.622(*)	-0.145	-0.016	-0.100	1			
	Sig (2-tailed)	0.163	0.351	0.290	0.749	0.017	0.621	0.955	0.733	.			
Zn	Pearson Correlation	-0.108	-0.133	0.267	0.314	-0.353	-0.309	-0.080	-0.108	-0.214	1		
	Sig (2-tailed)	0.714	0.649	0.356	0.274	0.216	0.282	0.785	0.712	0.464	.		
Na	Pearson Correlation	0.236	-0.268	-0.110	-0.355	0.460	-0.264	-0.480	-0.001	0.497	-0.173	1	
	Sig. (2-tailed)	0.417	0.355	0.709	0.213	0.098	0.362	0.082	0.997	0.070	0.555	.	
K	Pearson Correlation	0.067	0.037	-0.016	-0.175	-0.238	0.123	-0.273	0.267	0.122	-0.057	-0.007	1
	Sig. (2-tailed)	0.820	0.899	0.956	0.549	0.413	0.675	0.345	0.355	0.677	0.846	0.982	.

* Correlation is significant at the 0.05 level (2-tailed).

III (a) Pearson's Two-tailed Correlations among Water quality parameters inside the teagardens in the postmonsoon season

		HARDNESS	TS	TSS	TDS	Alkalinity	EC	Cl^-	SO_4^{2-}	DO	NO_3^{-1}	PO_4^{-3}	F-	1
HARDNESS	Pearson Correlation	1												
	Sig. (2-tailed)	.												
TS	Pearson Correlation	-0.382	1											
	Sig. (2-tailed)	0.177	.											
TSS	Pearson Correlation	-0.247	0.818**	1										
	Sig. (2-tailed)	0.395	0.000	.										
TDS	Pearson Correlation	-0.410	0.986**	0.764**	1									
	Sig. (2-tailed)	0.146	0.000	0.001	.									
Alkalinity	Pearson Correlation	0.155	0.342	0.309	0.374	1								
	Sig. (2-tailed)	0.596	0.232	0.283	0.187	.								
EC	Pearson Correlation	0.632*	-0.226	-0.156	-0.238	0.079	1							
	Sig. (2-tailed)	0.015	0.437	0.594	0.412	0.788	.							
Cl^-	Pearson Correlation	-0.133	0.229	0.273	0.268	-0.152	0.120	1						
	Sig. (2-tailed)	0.651	0.430	0.346	0.355	0.605	0.684	.						
SO_4^{2-}	Pearson Correlation	-0.113	0.721**	0.723**		0.547*	-0.230	-0.128	1					
	Sig. (2-tailed)	0.700	0.004	0.004	0.009	0.043	0.430	0.662	.					
DO	Pearson Correlation	0.343	0.088	-0.020	0.081	0.446	-0.172	-0.294	0.162	1				
	Sig. (2-tailed)	0.231	0.765	0.947	0.782	0.110	0.557	0.308	0.581	.				
NO_3^{-1}	Pearson Correlation	0.015	0.380	0.343	0.395	0.715**	-0.399	-0.246	0.673**	0.611*	1			
	Sig. (2-tailed)	0.960	0.180	0.230	0.162	0.004	0.157	0.397	0.008	0.020	.			
PO_4^{-3}	Pearson Correlation	0.089	0.438	0.340	0.434	0.392	0.105	0.325	0.135	0.282	0.182	1		
	Sig. (2-tailed)	0.763	0.117	0.234	0.121	0.165	0.722	0.258	0.644	0.329	0.533	.		
F-	Pearson Correlation	0.192	-0.228	-0.397	-0.211	0.260	-0.027	-0.410	0.029	0.059	0.153	0.275	1	
	Sig. (2-tailed)	0.510	0.433	0.159	0.469	0.370	0.928	0.146	0.920	0.842	0.602	0.341	.	
Turbidity	Pearson Correlation	-0.412	0.280	0.528	0.269	-0.048	-0.528	-0.036	0.361	-0.060	0.335	-0.105	-	
	Sig. (2-tailed)	0.144	0.333	0.052	0.352	0.872	0.052	0.903	0.205	0.839	0.242	0.720	0.275	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)

III (b) Pearson's Two-tailed Correlations among Water quality parameters inside the teagardens in the postmonsoon Season

		pH	Ca	Mg	Fe	Cu	Mn	As	Pb	Cd	Zn	Na	K
pH	Pearson Correlation	1											
	Sig (2-tailed)	.											
Ca	Pearson Correlation	0.106	1										
	Sig (2-tailed)	0.719	.										
Mg	Pearson Correlation	-0.171	-0.120	1									
	Sig (2-tailed)	0.558	0.682	.									
Fe	Pearson Correlation	0.199	-0.105	-0.017	1								
	Sig (2-tailed)	0.496	0.720	0.953	.								
Cu	Pearson Correlation	0.525	0.059	-0.594*	-0.001	1							
	Sig (2-tailed)	0.054	0.841	0.025	0.998	.							
Mn	Pearson Correlation	0.083	0.140	0.110	-0.230	-0.202	1						
	Sig. (2-tailed)	0.778	0.634	0.708	0.428	0.488	.						
As	Pearson Correlation	-0.232	-0.169	0.089	0.444	-0.208	-0.069	1					
	Sig (2-tailed)	0.426	0.563	0.763	0.112	0.476	0.815	.					
Pb	Pearson Correlation	-0.205	0.100	0.080	-0.272	-0.222	0.609*	-0.166	1				
	Sig (2-tailed)	0.481	0.735	0.786	0.346	0.445	0.021	0.571	.				
Cd	Pearson Correlation	0.202	-0.006	0.008	0.301	0.439	-0.177	0.525	-0.228	1			
	Sig. (2-tailed)	0.488	0.984	0.977	0.296	0.117	0.545	0.054	0.434	.			
Zn	Pearson Correlation	-0.127	0.053	0.241	0.653*	-0.323	-0.303	0.055	-0.192	-0.037	1		
	Sig (2-tailed)	0.664	0.857	0.406	0.011	0.260	0.292	0.853	0.511	0.899	.		
Na	Pearson Correlation	0.293	-0.102	-0.247	-0.292	0.530	-0.289	-0.384	-0.017	0.251	-0.320	1	
	Sig (2-tailed)	0.309	0.729	0.395	0.311	0.051	0.316	0.175	0.955	0.388	0.265	.	
K	Pearson Correlation	0.397	0.015	0.201	0.050	-0.027	-0.173	-0.459	0.108	-0.078	0.057	0.286	
	Sig (2-tailed)	0.160	0.959	0.491	0.865	0.927	0.555	0.099	0.714	0.792	0.846	0.321	

* **Correlation is significant at the 0.05 level (2-tailed).**

Table 5.6: Correlation table for water quality parameters inside the tea gardens

IV (a) Pearson's Two-tailed Correlations among Water quality parameters outside the teagardens in the premonsoon season

		HARDNESS	TS	TSS	TDS	Alkalinity	EC	Cl^-	SO_4^{2-}	DO	NO_3^{-1}	PO_4^{-3}	F-	T
HARDNESS	Pearson Correlation	1												
	Sig (2-tailed)	.												
TS	Pearson Correlation	0.134	1											
	Sig (2-tailed)	0.649	.											
TSS	Pearson Correlation	0.097	0.657*	1										
	Sig (2-tailed)	0.740	0.011	.										
TDS	Pearson Correlation	0.153	0.977**	0.661*	1									
	Sig (2-tailed)	0.601	0.000	0.010	.									
Alkalinity	Pearson Correlation	0.221	0.223	0.256	0.313	1								
	Sig (2-tailed)	0.447	0.443	0.378	0.275	.								
EC	Pearson Correlation	0.443	-0.148	-0.252	-0.162	0.329	1							
	Sig. (2-tailed)	0.113	0.614	0.385	0.579	0.250	.							
Cl^-	Pearson Correlation	-0.226	0.173	0.158	0.124	-0.069	-0.445	1						
	Sig (2-tailed)	0.437	0.553	0.589	0.672	0.813	0.110	.						
SO_4^{2-}	Pearson Correlation	-0.061	0.476	0.229	0.414	0.516	0.140	0.121	1					
	Sig (2-tailed)	0.835	0.085	0.431	0.141	0.059	0.633	0.680	.					
DO	Pearson Correlation	0.242	0.095	0.557*	0.065	0.247	-0.022	0.304	0.229	1				
	Sig (2-tailed)	0.404	0.746	0.039	0.826	0.395	0.939	0.290	0.432	.				
NO_3^{-1}	Pearson Correlation	-0.136	0.553*	0.594*	0.641*	0.386	-0.316	-0.200	0.203	0.032	1			
	Sig. (2-tailed)	0.643	0.040	0.025	0.014	0.173	0.271	0.494	0.486	0.912	.			
PO_4^{-3}	Pearson Correlation	0.203	0.645*	0.391	0.677*	0.179	-0.120	0.080	-0.098	-0.006	0.305	1		
	Sig (2-tailed)	0.487	0.013	0.166	0.008	0.541	0.683	0.786	0.739	0.984	0.289	.		
F-	Pearson Correlation	0.333	0.353	0.090	0.437	0.035	-0.168	-0.081	-0.264	-0.474	0.186	0.449	1	
	Sig. (2-tailed)	0.244	0.215	0.760	0.118	0.905	0.565	0.784	0.362	0.087	0.525	0.107	.	
Turbidity	Pearson Correlation	0.252	0.510	0.424	0.474	-0.240	-0.160	0.117	-0.213	-0.109	0.156	0.526	0.477	
	Sig. (2-tailed)	0.385	0.062	0.130	0.087	0.409	0.585	0.692	0.464	0.711	0.595	0.053	0.084	

** Correlation is significant at the 0.01 level (2-tailed).

- Correlation is significant at the 0.05 level (2-tailed).

IV (b) Pearson's Two-tailed Correlations among Water quality parameters outside the teagardens in the premonsoon season

		pH	Ca	Mg	Fe	Cu	Mn	As	Pb	Cd	Zn	Na	K
pH	Pearson Correlation	1											
	Sig (2-tailed)	.											
Ca	Pearson Correlation	-0.195	1										
	Sig (2-tailed)	0.504	.										
Mg	Pearson Correlation	0.164	0.646*	1									
	Sig (2-tailed)	0.575	0.013	.									
Fe	Pearson Correlation	-0.336	-0.024	-0.190	1								
	Sig (2-tailed)	0.240	0.936	0.515	.								
Cu	Pearson Correlation	0.538*	-0.210	-0.159	-0.282	1							
	Sig. (2-tailed)	0.047	0.470	0.588	0.329	.							
Mn	Pearson Correlation	0.423	0.283	0.326	-0.124	0.454	1						
	Sig (2-tailed)	0.131	0.326	0.256	0.674	0.103	.						
As	Pearson Correlation	-0.282	-0.053	-0.055	0.387	-0.149	-0.276	1					
	Sig (2-tailed)	0.329	0.858	0.852	0.172	0.611	0.340	.					
Pb	Pearson Correlation	-0.113	-0.090	-0.419	0.462	-0.106	0.252	-0.308	1				
	Sig (2-tailed)	0.700	0.760	0.136	0.096	0.718	0.385	0.284	.				
Cd	Pearson Correlation	-0.573*	0.462	0.367	-0.063	-0.167	-0.201	0.010	-0.339	1			
	Sig. (2-tailed)	0.032	0.096	0.197	0.831	0.568	0.491	0.973	0.235	.			
Zn	Pearson Correlation	-0.313	-0.341	-0.306	-0.309	0.255	-0.022	-0.128	0.115	0.035	1		
	Sig (2-tailed)	0.275	0.232	0.287	0.283	0.380	0.940	0.664	0.695	0.906	.		
Na	Pearson Correlation	-0.046	-0.181	-0.347	0.335	0.524	-0.031	0.075	0.136	0.289	0.080	1	
	Sig (2-tailed)	0.876	0.537	0.225	0.242	0.054	0.915	0.798	0.643	0.316	0.786	.	
K	Pearson Correlation	0.312	0.175	0.133	0.038	0.076	0.174	-0.472	0.469	-0.184	-0.130	-0.008	
	Sig (2-tailed)	0.277	0.551	0.651	0.897	0.796	0.551	0.089	0.091	0.529	0.657	0.978	

* **Correlation is significant at the 0.05 level (2-tailed).**

V (a) Pearson's Two-tailed Correlations among Water quality parameters outside the teagardens in the postmonsoon season

		HARDNESS	TS	TSS	TDS	Alkalinity	EC	Cl^-	SO_4^{2-}	DO	NO_3^{-1}	PO_4^{-3}	F-	T
HARDNESS	Pearson Correlation	1												
	Sig. (2-tailed)	.												
TS	Pearson Correlation	0.267	1											
	Sig. (2-tailed)	0.357	.											
TSS	Pearson Correlation	0.485	0.285	1										
	Sig (2-tailed)	0.079	0.323	.										
TDS	Pearson Correlation	0.244	0.999**	0.236	1									
	Sig (2-tailed)	0.400	0.000	0.416	.									
Alkalinit	Pearson Correlation	0.289	0.339	-0.016	0.344	1								
y	Sig (2-tailed)	0.316	0.236	0.957	0.229	.								
EC	Pearson Correlation	0.368	-0.143	-0.224	-0.133	0.120	1							
	Sig (2-tailed)	0.195	0.627	0.442	0.650	0.684	.							
Cl^-	Pearson Correlation	0.080	0.018	0.497	-0.011	-0.135	-	1						
	Sig (2-tailed)	0.786	0.951	0.070	0.969	0.646	0.006	.						
SO_4^{2-}	Pearson Correlation	0.277	0.416	0.468	0.399	0.562*	0.096	-0.206	1					
	Sig (2-tailed)	0.337	0.139	0.091	0.158	0.037	0.743	0.481	.					
DO	Pearson Correlation	0.267	0.239	0.313	0.223	-0.009	-0.167	0.349	0.263	1				
	Sig (2-tailed)	0.356	0.411	0.275	0.443	0.974	0.567	0.221	0.364	.				
NO_3^{-1}	Pearson Correlation	-0.065	0.319	0.078	0.319	0.521	-0.360	0.001	0.218	-0.205	1			
	Sig (2-tailed)	0.826	0.267	0.792	0.266	0.056	0.206	0.997	0.454	0.482	.			
PO_4^{-3}	Pearson Correlation	0.254	0.648*	-0.054	0.656*	0.342	0.006	-0.03	0.035	-0.017	0.401	1		
	Sig (2-tailed)	0.381	0.012	0.855	0.011	0.232	0.984	0.919	0.904	0.953	0.156	.		
F-	Pearson Correlation	-0.045	0.013	-0.096	0.016	0.286	-0.036	0.157	-0.323	-	0.371	0.400	1	
	Sig. (2-tailed)	0.879	0.965	0.744	0.956	0.321	0.904	0.591	0.260	0.008	0.192	0.156	.	
Turbidity	Pearson Correlation	0.636*	0.471	0.679**	0.438	0.216	0.002	0.398	0.264	0.242	0.178	0.469	0.158	
	Sig. (2-tailed)	0.015	0.089	0.008	0.118	0.458	0.994	0.158	0.362	0.405	0.542	0.091	0.589	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

V(b) Pearson's Two-tailed Correlations among Water quality parameters outside the teagardens in the postmonsoon season

		pH	Ca	Mg	Fe	Cu	Mn	As	Pb	Cd	Zn	Na	K
pH	Pearson Correlation	1											
	Sig (2-tailed)	.											
Ca	Pearson Correlation	-0.006	1										
	Sig (2-tailed)	0.983	.										
Mg	Pearson Correlation	0.177	0.819**	1									
	Sig. (2-tailed)	0.545	0	.									
Fe	Pearson Correlation	-0.270	0.287	0.232	1								
	Sig (2-tailed)	0.351	0.320	0.424	.								
Cu	Pearson Correlation	0.213	-0.327	-0.273	-0.466	1							
	Sig (2-tailed)	0.465	0.253	0.345	0.093	.							
Mn	Pearson Correlation	0.324	0.336	0.177	-0.235	0.598*	1						
	Sig. (2-tailed)	0.258	0.240	0.546	0.419	0.024	.						
As	Pearson Correlation	-0.357	-0.066	-0.168	0.468	0.001	-0.285	1					
	Sig (2-tailed)	0.211	0.822	0.566	0.092	0.997	0.323	.					
Pb	Pearson Correlation	-0.133	-0.204	-0.367	0.137	-0.238	-0.051	-0.314	1				
	Sig (2-tailed)	0.650	0.485	0.197	0.641	0.413	0.862	0.274	.				
Cd	Pearson Correlation	-0.638*	0.413	0.529	0.214	-0.233	-0.158	0.057	-0.175	1			
	Sig. (2-tailed)	0.014	0.142	0.052	0.463	0.422	0.591	0.846	0.549	.			
Zn	Pearson Correlation	-0.458	-0.408	-0.410	-0.529	0.385	0.015	-0.026	-0.032	0.114	1		
	Sig (2-tailed)	0.100	0.148	0.146	0.052	0.174	0.960	0.930	0.915	0.697	.		
Na	Pearson Correlation	-0.249	-0.143	-0.022	-0.118	0.425	0.061	0.234	0.049	0.439	0.099	1	
	Sig. (2-tailed)	0.390	0.627	0.941	0.688	0.130	0.836	0.420	0.869	0.116	0.736	.	
K	Pearson Correlation	-0.040	0.095	-0.084	0.07	0.407	0.671**	-0.15	0.000	-0.096	0.248	-0.239	
	Sig. (2-tailed)	0.892	0.746	0.775	0.812	0.148	0.009	0.609	1.000	0.744	0.393	0.411	

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The key recommendations of this study are to take a more strategic approach to the soil and water quality indicators in the study area at project, regional and national levels. This includes the targeted integration of studied parameters as a risk factor in water supply and irrigation investments undertaken in the area, rather than treating it as a special issue to be dealt with by special authorities or agencies. This study outlines that academia is needed to make soil and water related research more strategic and effective at a regional level. From the study, it is also recommended that a series of permanent sampling sites be established to determine long-term trends in soil quality, sites be monitored at least on a four-yearly basis so that trends can assessed for reporting on State of the Environment in the area. The feasibility of larger scale monitoring of soil quality using satellite imaging should be investigated. It is hoped that in bringing together and analyzing the past experience of such research, this study will contribute to the development of a more strategic and operational response to the soil and water quality issues so that concerted strategies can be made at the planning level to keep the contamination of soil and water at the minimum. As is evident from the correlation tables since most of the soil and water quality parameters are significantly correlated, so further studies are needed to assess the relationship between levels of these parameters with health risks. Assessing the scale of the problem (now and over time) involves field testing, laboratory testing, and monitoring; identifying appropriate mitigation strategies involves technological, economic, and socio-cultural analysis of possible responses; and implementation involves awareness raising and direct action by governments, donors, NGOs, and other stakeholders at local, national, and regional levels. Sustainability in the long run remains a major challenge. Finally, we need to apprehend that we are heading towards a catastrophe with no way of turning back. We should overcome this inevitable catastrophic syndrome by developing suitable management and conservation practices. The present study, however, fulfilled the limited purpose of strengthening database which may be helpful in formulating strategy for future protection of soil and water in the area.