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Baseline Profile of Soil Samples from Upian River Watershed

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Abstract

The Mines and Geosciences Bureau (MGB) in the Philippines is currently mapping out the entire Davao City Watershed Area (DCWA). There are 8 major watershed areas within DCWA that has been identified by the MGB and the largest is the Davao River Watershed Area (DRWA). A smaller sub-watershed within DRWA, the Upian River Watershed Area (URWA), was proposed of which its boundary and soil profile is yet to be established. This study focused on the analyses of the soil samples from URWA. The results for pH, organic matter, cation exchange capacity, N, P, K, Ca and Mg were then compared to the Bureau of Soil standard for its fertility rating. Analysis of lead (Pb) was also included as a pollutant indicator for possible soil contamination.

There are 4 sampling sites with unfavorable ratings for pH, 3 for both organic matter and phosphorus, and 2 stations for both nitrogen and calcium. Fertility rating is generally good for cation exchange capacity, potassium and magnesium. The Bureau of Soil has no existing standards for micronutrients. However, all sampling sites were found to be too low with micronutrients according to Gershuny and Smillie. No indication of lead contamination or pollution on all sites as far as natural levels of lead in surface soil is concerned. This study will provide baseline information that is useful to all stakeholders, to the people living near the area, farmers, planners, and resource managers. This can also provide inputs to key government agencies in the Philippines like the Department of Environment and Natural Resources (DENR) and the City Planning Office of Davao in formulating policies for sustainable management of the resource upon implementation of their programs and projects. Without the aforementioned information, planners would have difficulty in predicting the impact or recommend best management strategies for a specific land use.

Keywords: Upian River Watershed Area, watershed, baseline profile, fertility

Introduction

Most life on earth depends on soil as a source of food, livelihood, habitat, foundation of buildings, preserves clean water and civilization. However, this most important renewable resource has always been poorly understood, which usually ends with mismanagement and overexploitation. Several experts and studies have questioned whether food security could be achieved amidst many challenges including climate change, an ever-increasing world population, depletion of water resources, soil desertification, and deforestation [1]. Approximately 2 billion hectares of land are degraded since 1945. The causes of this degradation are overgrazing, agricultural activities, deforestation, over exploitation and industrialization. Wind and water erosion are the principal mechanisms of this soil degradation. It accounts for about 56 and 28 % respectively for wind and water. Chemical degradation due to insufficient manure and fertilizer, soil acidification not corrected by liming, and pollution caused by industrial and other urban uses is 12 %. The remaining 4 % is physical degradation from compaction or flooding [2]. With the fast economic development, land-use has changed dramatically in the last 2 decades. Increase in the residential land use has expanded lately especially in urban areas. Population explosion is the main driving force for land-use change but state macroscopic agricultural policies must also play an important role in structural changes [3]. Since every life depends on soil, conservation and management is critical. Soil management is also about protecting the watershed. Soil testing or analysis of soil nutrients is a very important step in the conservation of soil for understanding the composition of soil that can further help in the management of soil. Hati *et al.* showed that one of the main elements to assure soil fertility is the maintenance of optimum physical soil conditions through the application of conservation practices. They further corroborated that the decline of nutrient contents in soil, especially organic matter, is associated with the physical degradation of soil [4].

The Mines and Geosciences Bureau (MBG) is presently in the process of delineating sub-watershed areas. There are 8 major sub-watershed areas identified by the MGB within the Davao City Watershed. The largest of which is the Davao River Watershed Area (DRWA). So far, there are 2 identified sub-watershed areas within DRWA; the Tamugan River Watershed and Cugan Creek Watershed areas. Another proposed sub-watershed area within DRWA is the URWA. The boundary of the area is to yet be established as well as its soil profile. The Upian River Watershed Area (URWA) is part of the third Congressional District of Davao and within Marilog District. Marilog District is the second largest administrative district of Davao City, Philippines and has a total land area of 63,800 hectares. Marilog district is very diverse in terms of its agricultural products such as rice, corn, root vegetables, fruit vegetables, leafy vegetables, root crops, fruits and industrial crops [5]. There are 3 barangays comprising URWA. These are portions of Marilog proper (8 sampling sites), Baganihan (1 sampling site) and part of Datu Salumay (4 sampling sites). The populations per barangay are 13,966, 1,088 and 1,509 respectively for Marilog proper, Baganihan and Datu Salumay [6]. The total land area of the study area (URWA) is approximately 12,000 hectares [7]. The Department of Environment and Natural Resources (DENR) through its service office, the Mines and Geosciences Bureau - Region XI (MGB-XI) in coordination with the Davao City Planning Office (DCPO) are currently intensifying their efforts in determining the soil baseline profile of the whole Davao City Watershed. Thus, this study will complement the physical data of the soil already established by the MGB and profile the chemical tests of the soil samples from the Upian River Watershed Area (URWA) - a sub-watershed of the bigger Davao City Watershed.

Materials and methods

The soil was taken by digging out about 30 centimeters using a soil borer. Two kilograms of soil sample for every sampling station were collected and placed in plastic bags. The samples were then ground, pulverized and sieved via a 0.50 mm mesh sieve after air drying for at least 24 h. The sieved soil was placed in a clean cellophane bag and ready for analysis. The standard methodology and laboratory procedures suggested by Philippine Council for Agriculture and Resources Research (PCARR) [8] and Official Method of Analysis of Association of Official Analytical Chemists (AOAC) [7] were used in the determination of soil pH, cation exchange capacity (CEC), organic matter (OM), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), exchangeable calcium (Ca), exchangeable magnesium (Mg), total iron (Fe), total manganese (Mn), total zinc (Zn), and total lead (Pb). Three trials per sample were analyzed for all parameters except nitrogen (N) where only two trials were conducted.

Soil pH determination by glass electrode method

Three grams of the previously sieved soil was weighed into a 50 mL beaker and added with 20 mL deionized water. The mixture was stirred and mixed well using a magnetic stirrer and allowed to stand for 1 h. The pH meter was calibrated by using standard buffer solutions 4.0 and 7.0. The suspension was stirred and the pH was read immediately.

Organic matter (as sucrose) determination by graham colorimetric method

A soil sample of about 1.0 g was weighed analytically and placed in a 125 mL Erlenmeyer flask and 10 mL of 0.167 M $K_2Cr_2O_7$ solution was added. The solution was swirled and 20 mL of concentrated H_2SO_4 was added rapidly as this procedure was done in the hood. The reaction was then allowed to complete for 30 min. Sixty mL of distilled water was added and the mixture was allowed to stand overnight. A portion of the clear solution was decanted into the colorimeter test tubes. The absorbance at 589.06 nm was then read using the UV-Vis spectrophotometer. A standard curve of sucrose solution was used to determine the organic matter content in soil. A third sample treated with the same procedure was spiked by adding 28.50 mL of 5 % Organic Carbon (% OC) to 1.0 g soil sample. The reaction between carbon and $K_2Cr_2O_7$ were carried out in sulfuric acid solution and is represented by the equation below.

$$3C + 2Cr_2O_7^{2-} + 16H^+ \longrightarrow 3CO_2 + 4Cr^{3+} + 8H_2O$$

Cation exchange capacity by titrimetric method

Two grams of soil sample was weighed and placed in a 250 mL Erlenmeyer flask and 100 mL of 0.5 M HCl was added into it. The flask was then stoppered to prevent spilling of the solution and was shaken using a mechanical shaker for 30 min. The mixture was filtered and the residue washed (10 mL of water for each washing) until the filtrate no longer showed signs of precipitate formation upon addition of 3 mL 1 % $AgNO_3$. The filtrate was discarded and residue transferred into a 250 mL Erlenmeyer flask with the aid of a wash bottle containing 100 mL of 0.25 M barium acetate. The flask was stoppered and shaken for 30 min. The mixture was then filtered and washed with three 100 mL portions of water. The residue was discarded and the filtrate was titrated with a standard 0.0917 M NaOH using phenolphthalein indicator until a pale pink endpoint was reached. A blank sample was determined also using similar treatment and reagents but without the sample.

Total nitrogen

A soil sample of 0.80 to 1.00 g was weighed and transferred in a Kjeldahl flask. Fifteen grams of powdered potassium sulfate, 0.7 g HgO, and 25 mL of concentrated sulfuric acid were added to the sample. The sample was mixed thoroughly and heated in an inclined position in order to convert organic nitrogen to ammonium sulfate. The digestion continued until the blackish color disappeared and became clear in color. The mixture was allowed to cool and was then added with 200 mL of water. A steam distillation set-up was constructed after the digestion. The Kjeldahl flask, in a tilted position, was attached to a condenser and a 250 mL Erlenmeyer flask to collect the distillate at the other end. A 100 mL of 40 % NaOH solution was poured slowly without agitation. The tip of the condenser was immersed in the receiver flask which contained 50.00 mL of 0.1011 M standardized HCl with 5 to 7 drops of the phenolphthalein indicator. The distillation was stopped until the receiver flask contained a total volume of 150 mL. The distillate was then titrated with standard 0.0893 M NaOH until a faint-pink end point color was reached. The same procedure and endpoint was followed for a blank solution but in the absence of the soil sample.

Phosphorus determination by Troug method

One gram of soil sample was weighed accurately and placed in a 250 mL Erlenmeyer flask. One hundred milliliters of Troug solution was added and the solution was shaken for 30 min in the mechanical shaker. The solution was filtered and 25.00 mL aliquot was placed into a 125 mL Erlenmeyer flask. Two milliliters of molybdate reagent and two drops $SnCl_2$ were added and mixed thoroughly. The sample was then run and read in the UV-Vis spectrophotometer at 700.31 nm. A spike was also added to a third sample to calculate the percent recovery.

Reactions;

$$H_3PO_4 + 12H_2MoO_4 \longrightarrow H_3P(Mo_3O_{10})_4 + 12H_2O$$

$$H_3P(MoO_{10})_4 + N_2H_2SO_4 \longrightarrow \text{Blue product}$$

Exchangeable cations (K, Ca and Mg) determination

One gram of air-dried soil was weighed accurately into a 100 mL beaker and added with 10 mL of 1 M ammonium acetate. The mixture was stirred, covered and allowed to stand overnight. The mixture was filtered and the residue washed with ammonium acetate. The filtrate was transferred into a 50.00 mL volumetric flask and was diluted to the mark with ammonium acetate. The ammonium extract was transferred into a 100 mL beaker and was evaporated until a relatively smaller volume remains. The beaker was covered with a watch glass and allowed to cool. Five mL of fuming nitric acid and 1 mL of concentrated HCl was added slowly through the lip of the beaker. The solution was warmed on a hot plate until the reaction had subsided and the brown fumes were no longer given off. The watch glass was rinsed with distilled water into the beaker and the solution was evaporated to dryness at low heat to prevent spattering. The beaker was then heated for 15 min after the electric muffle gradually reached 390 °C ± 10 °C. The beaker was removed from the muffle and allowed to cool. The residue was then treated with 3 mL of dilute HCl (1:1) to dissolve the oxides of manganese, iron and aluminum. The solution was evaporated to dryness for 15 min, cool and 12.5 mL of 0.1 M HNO_3 was added immediately. The solution was stirred with a stirring rod to dissolve the residue of salts. The solution was then filtered and the filtrate was diluted to 50.00 mL with 0.1 M HNO_3. The diluted filtrate was saved for K, Ca and Mg determination using AAS. An aliquot of 1.00 mL of the filtrate was diluted to 50.00 mL with 0.1 M HNO_3 for the determination of K. For the determination of Ca, a 1.00 mL aliquot of the filtrate was added with 5 mL $SrCl_2$ and diluted to 50.00 mL with 0.1 M HNO_3. For Mg determination, a 1.00 mL aliquot was added with 5 mL $SrCl_2$ and diluted to 50.00 mL with 0.1 M HNO_3. Another 1.00 mL of the resulting solution was further diluted to 50.00 mL with 0.1 M HNO_3. Dilution factor varies per sample and per cation analysis. To get the meq cation / 100 g of soil, the corrected ppm of the cation is converted into milliequivalents via the atomic masses of the cation with their respective equivalents.

Determination of Fe, Mn, Zn and Pb

A soil sample of about 1.0 g was weighed in a 100 mL beaker and 10 mL of aqua regia was added. The solution was covered and stood overnight then heated until half of the volume remains. The solution was then cooled and transferred into a 100.00 mL volumetric flask and was diluted up to the mark with distilled water. The solution was filtered and the filtrate saved for the determination of Fe, Mn, Zn and Pb using AAS. One mL aliquot of the filtrate was taken and diluted to 100.00 mL with distilled water and 5 milliliter aliquot of the new solution was diluted further to 50.00 mL with distilled water for Fe determination. Five mL aliquot of the filtrate was also taken and diluted to 100.00 mL with distilled water for the determination of Mn. Twenty-five milliliter aliquot of the filtrate was also taken and diluted to 100.00 mL with distilled water for Zn determination. The original solution was used for the determination of Pb.

Results and discussion

The dotted line shown in **Figure 1** is the suggested boundary of the URWA. The dots are the sampling stations of this study. The result of analyses of various chemical parameters in comparison to the standard values set by the Bureau of Soils and Water Management [10] are as follows;

pH

Of the 13 soil samples from URWA, RTV 17 has the highest pH (6.75) while EIS 37B has the lowest pH of 4.91. This would mean that the sampling station EIS 37B together with stations RTV 13, EIS 25B and EIS 39B are strongly acidic and unfavorable as far as the Bureau of Soils Fertility Rating [10] is concerned. Acid loving plants like berries and azaleas will most likely endure and survive in the said areas. These 4 stations need addition of pH-enhancing chemicals such as urea, wood ashes and lime to correct it. However, synthetic fertilizers are generally more available, less expensive and have quicker results. Topography and presence of various land cover are 2 other contributing factors that can affect acidity of soil. Applying the calculated standard deviation, the upper pH range of EIS 25B falls under moderately favorable instead of unfavorable and the lower pH range of EIS 38B is unfavorable instead of moderately favorable while all other stations are the same. The pH results are shown in **Table 1** while the map of pH of the 13 soil samples from the URWA are shown in **Figure 1**.

Table 1 Mean pH per sampling station

Sample	Mean pH
RTV 13	4.97 ± 0.01
RTV 15	5.73 ± 0.04
RTV 16	6.49 ± 0.07
RTV 17	6.75 ± 0.03
RTV 19	6.50 ± 0.04
RTV 22	6.31± 0.03
EIS 25A	5.93 ± 0.08
EIS 25B	4.99 ± 0.08
EIS 35A	6.49 ± 0.09
EIS 36B	6.27 ± 0.07
EIS 37B	4.91± 0.03
EIS 38B	5.03 ± 0.06
EIS 39B	4.93 ± 0.04

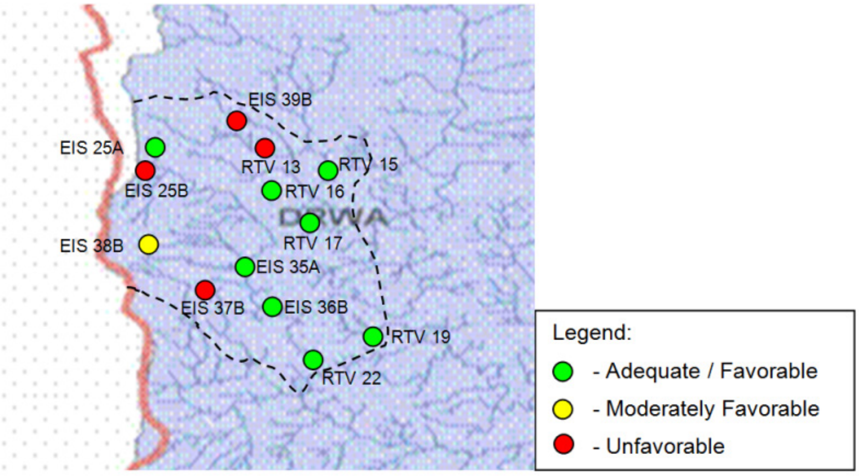

Figure 1 Map of pH in URWA.

Organic matter (OM)

The highest percent organic matter is found in station EIS 25A and the lowest is EIS 37B. Sampling stations RTV 15, RTV 16 and EIS 37B are unfavorable per Bureau of Soils fertility rating [10] and needs soil-organic matter-boosting materials like manures, sawdust, and synthetic fertilizers. However, stations RTV 13, EIS 25A, EIS 35A and EIS 39B are adequate or favorable. It can be noted that these areas are either moist or wet. High organic matter increases water holding capacity of the soil. The observed

Bureau of Soil fertility rating [10] of each station is still the same even if lower and upper range of the calculated standard deviation is applied. The organic matter results are in **Table 2** as well as the map of % OM of the 13 soil samples from URWA in **Figure 2**.

Table 2 OM per sampling station.

Sample	% OM
RTV 13	3.98 ± 0.13
RTV 15	1.45 ± 0.04
RTV 16	1.51 ± 0.00
RTV 17	2.45 ± 0.04
RTV 19	2.48 ± 0.00
RTV 22	2.42 ± 0.09
EIS 25A	4.94 ± 0.13
EIS 25B	1.78 ± 0.01
EIS 35A	3.68 ± 0.02
EIS 36B	2.40 ± 0.02
EIS 37B	1.00 ± 0.08
EIS 38B	2.03 ± 0.08
EIS 39B	3.03 ± 0.02

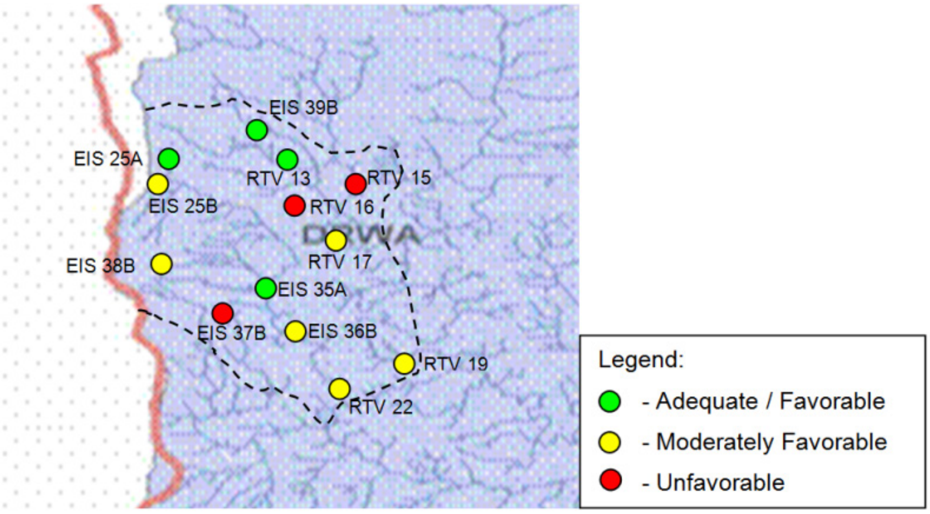

Figure 2 Map of % organic matter in URWA.

Cation Exchange Capacity (CEC)

The cation exchange capacity of the 13 sampling stations is generally good with Bureau of Soils fertility rating [10] of moderately favorable to adequate/favorable. This is due to the fact that majority of the sampling sites have a clay soil-type. Secondly, almost all stations showed high concentrations of organic matter. The more clay and organic matter in the soil, the higher the CEC will be. Although EIS 25A was classified by MGB as loamy-sand, it has still had high pH which therefore favors an increase in the CEC of the soil. Applying the calculated standard deviation, the upper CEC range of RTV 16 falls under adequate/favorable instead of moderately favorable while all other stations are the same. The CEC results in table as well as the map of the 13 soil samples from URWA are shown in **Figure 3**.

Table 3 Mean CEC per sampling station.

Sample	Mean CEC in Meq/100g soil
RTV 13	42.57 ± 0.18
RTV 15	45.12 ± 0.07
RTV 16	19.7 ± 2.0
RTV 17	21.85 ± 0.60
RTV 19	31.71 ± 0.14
RTV 22	34.78 ± 0.17
EIS 25A	18.38 ± 0.24
EIS 25B	13.17 ± 0.29
EIS 35A	23.95 ± 0.94
EIS 36B	36.28 ± 0.21
EIS 37B	34.93 ± 0.36
EIS 38B	34.57 ± 0.27
EIS 39B	30.29 ± 0.27

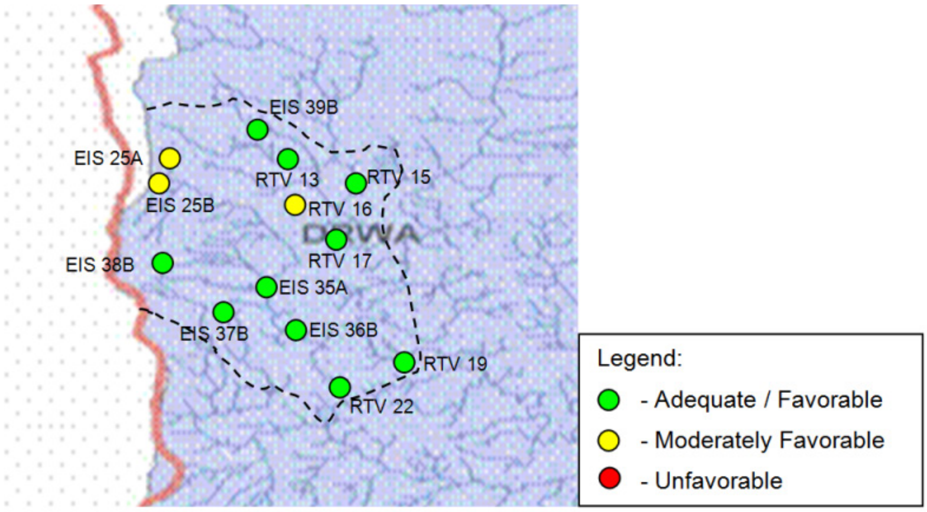

Figure 3 Map of CEC (meq/100 g) in URWA.

Total nitrogen (N)

The highest percent nitrogen is in station RTV 13 (0.3511 %) with adequate/favorable Bureau of Soils fertility rating [10]. EIS 38B and EIS 39B have the lowest percent nitrogen value of 0.0715 % and 0.0889 %, respectively. Deficiency of nitrogen in these areas can possibly reduce plant growth and lowers crop production. Application of synthetic fertilizers, manure and planting of nitrogen-fixing legumes on both stations are needed to improve the nitrogen content of the soil. However, the nitrogen content is generally moderate because nitrogen is not as available in wet soils. Applying the calculated standard deviation, the upper % N range of EIS 39B falls under moderately favorable instead of unfavorable while all other stations are the same. The % Nitrogen results are given in **Table 4** while the map of the 13 soil samples from URWA are shown in **Figure 4**.

Table 4 Mean % N per sampling station.

Sample	% Total N in soil
RTV 13	0.35 ± 0.11
RTV 15	0.18 ± 0.08
RTV 16	0.11 ± 0.04
RTV 17	0.10 ± 0.01
RTV 19	0.11 ± 0.01
RTV 22	0.25 ± 0.02
EIS 25A	0.21 ± 0.04
EIS 25B	0.20 ± 0.04
EIS 35A	0.25 ± 0.02
EIS 36B	0.26 ± 0.01
EIS 37B	0.14 ± 0.03
EIS 38B	0.07 ± 0.01
EIS 39B	0.09 ± 0.05

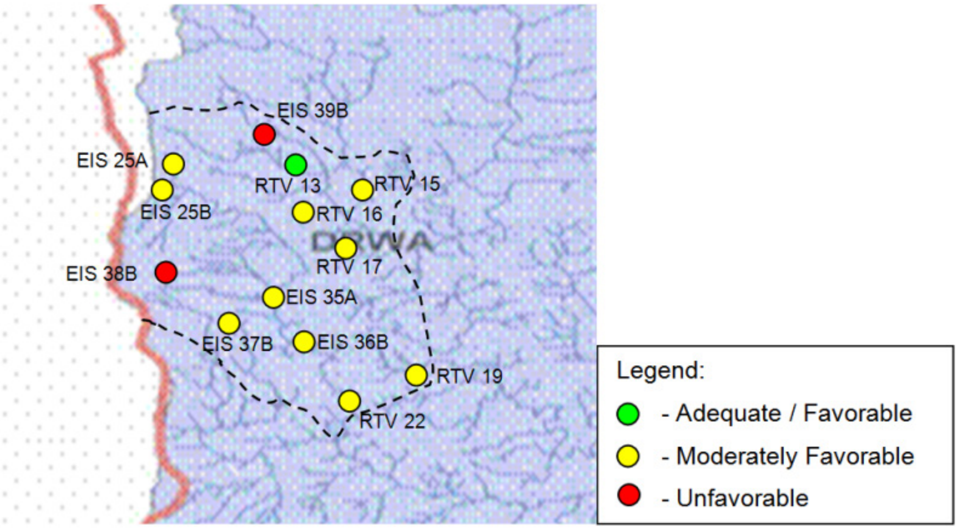

Figure 4 Map of % nitrogen in URWA.

Phosphorus (P)

Station RTV 16 has the highest phosphorus concentration of 81.7715 ppm while EIS 25A has the least with 1.8336 ppm. RTV 17, RTV 19 and EIS 25A are unfavorable and need soil amendments per the Bureau of Soils fertility rating standard [10]. Corrective measures like addition of animal manures are inexpensive soil amendment but synthetic fertilizers generally have quicker results. Applying the calculated standard deviation; the upper phosphorus range of RTV 19 falls under moderately favorable instead of unfavorable, the lower range of EIS 36B is moderately favorable instead of adequate/favorable while lower range of EIS 39B is unfavorable instead of moderately favorable. The results of phosphorus are given in **Table 5** and the map of the 13 soil samples from URWA are in **Figure 5**.

Table 5 Phosphorus per sampling station.

Sample	Phosphorus in soil (ppm)
RTV 13	49.69 ± 0.80
RTV 15	16.66 ± 0.78
RTV 16	81.77 ± 0.23
RTV 17	2.40 ± 0.56
RTV 19	5.46 ± 0.56
RTV 22	50.81 ± 0.18
EIS 25A	1.83 ± 0.57
EIS 25B	6.83 ± 0.72
EIS 35A	13.81 ± 0.16
EIS 36B	10.18 ± 0.49
EIS 37B	8.97 ± 0.36
EIS 38B	12.7 ± 1.3
EIS 39B	6.70 ± 0.89

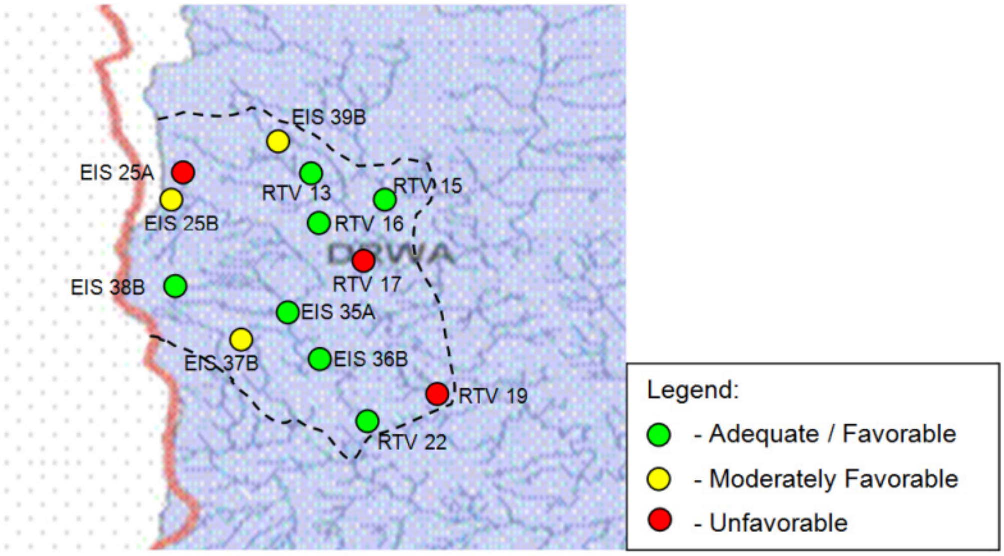

Figure 5 Map of phosphorus (ppm) in URWA.

Potassium (K)

The potassium content in all sampling stations is adequate or favorable. The excellent cation exchange capacity (CEC) of the soil promotes and assists the retention of potassium. The observed Bureau of Soil fertility rating [10] of all station is still the same even if lower and upper range of the calculated standard deviation is applied. The analysis result of potassium is in **Table 6** as well as the map of the 13 soil samples from URWA are shown in **Figure 6**.

Table 6 Potassium per sampling station.

Sample	ppm K
RTV 13	58.5 ± 1.6
RTV 15	28.0 ± 1.7
RTV 16	20.2 ± 1.1
RTV 17	5.13 ± 0.60
RTV 19	35.9 ± 2.0
RTV 22	25.5 ± 1.2
EIS 25A	10.8 ± 1.0
EIS 25B	5.36 ± 0.94
EIS 35A	18.9 ± 3.1
EIS 36B	32.8 ± 1.7
EIS 37B	65.3 ± 3.1
EIS 38B	84.5 ± 2.8
EIS 39B	30.2 ± 2.6

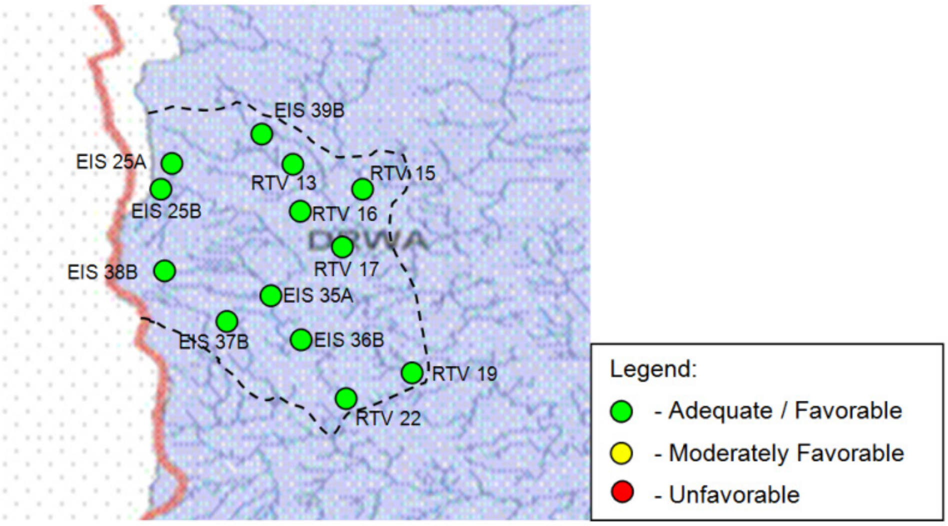

Figure 6 Map of potassium (ppm) in URWA.

Calcium (Ca)

The highest calcium concentration is found in RTV 16 (154.1899 ppm) while the lowest is at EIS 25B (1.2661 ppm). There are 2 sampling stations that were rated as unfavorable per the Bureau of Soil fertility rating standard [10] namely, EIS 25B and EIS 37B. The observed Bureau of Soil fertility rating [10] of all station is still the same even if lower and upper range of the calculated standard deviation is applied. The result for calcium is shown in **Table 7** with a map of the 13 soil samples from URWA in **Figure 7**.

Table 7 Calcium per sampling station.

Sample	ppm Ca
RTV 13	51.88 ± 0.36
RTV 15	125.48 ± 0.62
RTV 16	154.19 ± 0.28
RTV 17	39.4 ± 1.0
RTV 19	140.21 ± 0.13
RTV 22	63.72 ± 0.02
EIS 25A	7.7 ± 1.2
EIS 25B	1.27 ± 0.34
EIS 35A	141.4 ± 1.1
EIS 36B	107.73 ± 0.85
EIS 37B	1.77 ± 0.34
EIS 38B	19.13 ± 0.61
EIS 39B	4.72 ± 0.17

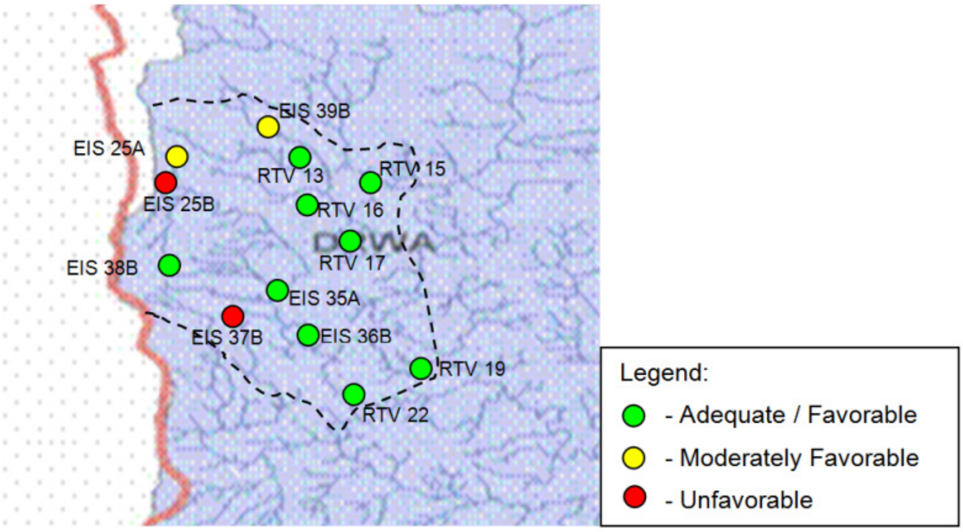

Figure 7 Map of Ca (ppm) in URWA.

Magnesium (Mg)

The soil condition as far as magnesium content is concerned in all sampling stations is adequate or favorable. The following figure shows the map of magnesium in ppm for each sampling site. The observed Bureau of Soil fertility rating [10] of all station is still the same even if lower and upper range of the calculated standard deviation is applied. The analysis result of calcium is in **Table 8** while the map of the 13 soil samples from URWA are shown in **Figure 8**.

Table 8 Magnesium per sampling station.

Sample	ppm Mg
RTV 13	137.95 ± 0.04
RTV 15	170.7 ± 1.6
RTV 16	651 ± 11
RTV 17	885 ± 33
RTV 19	361 ± 31
RTV 22	290 ± 10
EIS 25A	60 ± 20
EIS 25B	64 ± 17
EIS 35A	427 ± 19
EIS 36B	202 ± 17
EIS 37B	113.97 ± 0.42
EIS 38B	150 ± 20
EIS 39B	99 ± 21

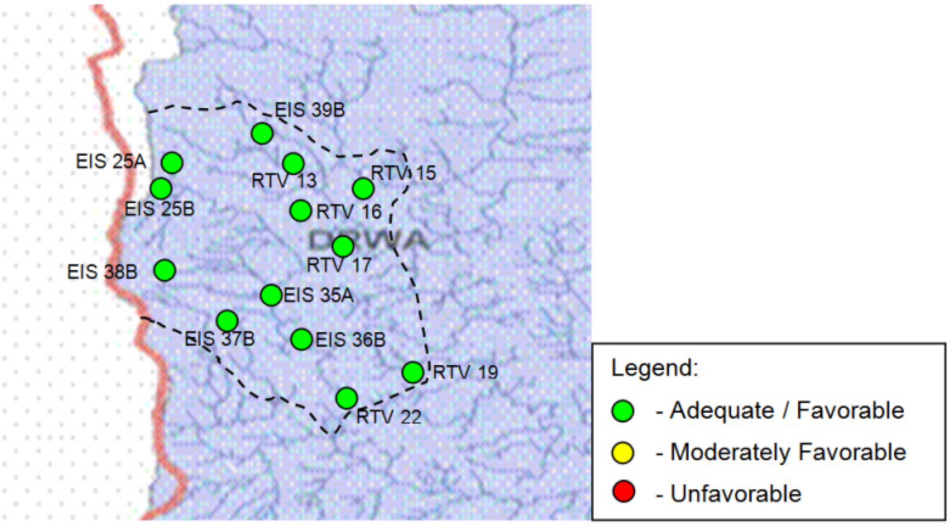

Figure 8 Map of Mg (ppm) in URWA.

Micronutrients

The highest micronutrient contents (Fe, Mn and Zn) are 5,108 ppm, 91.1 ppm and 2.037 ppm in stations EIS 25B, EIS 25A and EIS 35A, respectively. The lowest is at EIS 36B, EIS 39B and RTV 17 for Fe, Mn and Zn correspondingly. The Bureau of Soil [10] has no existing standards for micronutrients. However, according to Gershuny and Smillie [11], the desired amount in soil for Fe, Mn and Zn are 25,000 ppm, 2,500 ppm and 100 ppm, respectively. Using the aforementioned amount as a basis for soil micronutrient requirements, all sampling sites are too low than the desired figure. The absence of top soil in most of the sampling sites may have contributed to low micronutrients level. Topsoil carries considerable soil organic matter which held potentially available nutrients. Thus, removal of topsoil leads to deficiencies of some micronutrients [11]. The analysis result of micronutrients - iron, manganese and zinc are shown in **Table 9**.

Table 9 Iron, manganese, zinc and lead per sampling station.

Sample	ppm Fe / gram sample	ppm Mn / gram sample	ppm Zn / gram sample	ppm Pb / gram sample
RTV 13	2108 ± 33	10.27 ± 0.06	0.51 ± 0.03	0.05 ± 0.01
RTV 15	2393 ± 59	36.08 ± 0.41	0.81 ± 0.08	0.01 ± 0.01
RTV 16	1179 ± 83	34.35 ± 0.39	0.22 ± 0.02	0.02 ± 0.01
RTV 17	2355 ± 84	58.0 ± 1.6	0.04 ± 0.00	0.20 ± 0.01
RTV 19	1072 ± 11	28.98 ± 0.20	0.86 ± 0.10	0.06 ± 0.01
RTV 22	1271 ± 32	31.66 ± 0.79	0.51 ± 0.05	0.05 ± 0.07
EIS 25A	4650 ± 190	91.1 ± 1.1	1.76 ± 0.13	0.62 ± 0.00
EIS 25B	5108.3 ± 2.6	11.86 ± 0.45	0.86 ± 0.16	0.04 ± 0.05
EIS 35A	1130 ± 140	42.0 ± 1.2	2.04 ± 0.18	0.30 ± 0.02
EIS 36B	283 ± 21	25.98 ± 0.19	0.59 ± 0.06	0.02 ± 0.01
EIS 37B	512 ± 26	11.84 ± 0.25	1.70 ± 0.09	0.13 ± 0.05
EIS 38B	1846 ± 13	24.6 ± 1.2	0.64 ± 0.02	0.88 ± 0.03
EIS 39B	1996 ± 57	1.71 ± 0.15	0.26 ± 0.03	0.27 ± 0.03

Lead (Pb)

EIS 38B has the highest concentration of lead (0.8764 ppm) while RTV 15 has the least (0.0050 ppm). Natural level of lead in soil, ranges from 50 ppm to 400 ppm [12], hence, no indication of lead contamination or pollution on the said soil. The nonexistence of lead mining related activities, contamination with lead-based paints and absence of incinerators and motor vehicles that use leaded gasoline have contributed much to the low level of lead in the area. The analysis result of lead are in **Table 9**.

The condition of the soil when compared to the guidelines set by the Bureau of Soils [10] are summarized below in **Table 10**.

Table 10 Summary of rating as compared to Bureau of soils standard [10].

Sample	pH	OM	CEC	N	P	K	Ca	Mg
RTV 13	Unfav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
RTV 15	Adeq Fav	Unfav	Adeq Fav	Mod Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
RTV 16	Adeq Fav	Unfav	Mod Fav	Mod Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
RTV 17	Adeq Fav	Mod Fav	Adeq Fav	Mod Fav	Unfav	Adeq Fav	Adeq Fav	Adeq Fav
RTV 19	Adeq Fav	Mod Fav	Adeq Fav	Mod Fav	Unfav	Adeq Fav	Adeq Fav	Adeq Fav
RTV 22	Adeq Fav	Mod Fav	Adeq Fav	Mod Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
EIS 25A	Adeq Fav	Adeq Fav	Mod Fav	Mod Fav	Unfav	Adeq Fav	Mod Fav	Adeq Fav
EIS 25B	Unfav	Mod Fav	Mod Fav	Mod Fav	Mod Fav	Adeq Fav	Unfav	Adeq Fav
EIS 35A	Adeq Fav	Adeq Fav	Adeq Fav	Mod Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
EIS 36B	Adeq Fav	Mod Fav	Adeq Fav	Mod Fav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
EIS 37B	Unfav	Unfav	Adeq Fav	Mod Fav	Mod Fav	Adeq Fav	Unfav	Adeq Fav
EIS 38B	Mod Fav	Mod Fav	Adeq Fav	Unfav	Adeq Fav	Adeq Fav	Adeq Fav	Adeq Fav
EIS 39B	Unfav	Adeq Fav	Adeq Fav	Unfav	Mod Fav	Adeq Fav	Mod Fav	Adeq Fav

Legend;

Unfav	- unfavorable
Mod Fav	- moderately favorable
Adeq Fav	- adequately favorable

The following are strongly recommended for further studies;

1) More sampling sites must be established in order to have a comprehensive and representative sample of the whole URWA.

2) Regular soil analysis should be conducted to guide farmers on what specific crops can be grown in the area.

3) Soil amendments are strongly recommended on areas rated unfavorable by the Bureau of Soils standard.

4) Another study must be performed and compared during dry and rainy season.

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