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Assessment of hydrological properties of soils from textural analysis: a study in the Burhi Dihing-Noa Dihing interfluves, Assam

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ABSTRACT

Grain size analyses of the 43 representative soil samples collected from different localities of the interfluves between Burhi Dihing and Noa Dihing rivers, Assam have been carried out in the laboratory in order to determine their textural characteristics in terms of the percentage of sand, silt and clay present in each sample. Soil textural classes have also been determined by following standard method. From the cumulative curves, different size distributions viz. d_{10}, d_{25}, d_{60} *and* d_{75} *have been determined based upon which hydrological properties like effective grain size, sorting coefficient, uniformity coefficient and permeability of the soils are determined. These parameters point towards overall good infiltration characteristics of soils of the study area.*

Keywords : Soil texture, Effective size, Uniformity coefficient, Permeability, Porosity

Introduction

Soil is invariably present in most areas as a surface blanket layer through which the recharge from rainfall penetration has to take place. This rainfall recharge is governed by the textural characteristics of soil which, in turn, controls the hydrologic properties of soil responsible for infiltration of rainwater. In order to assess the hydrological properties of soils from textural analysis, a study was undertaken in the Burhi Dihing-Noa Dihing interfluves which is a part of the South Brahmaputra plains in Assam. For this purpose 43 soil samples were collected from different localities of the said area and analysed in the laboratory. The map showing location of the soil samples in the area is presented in Fig.1.

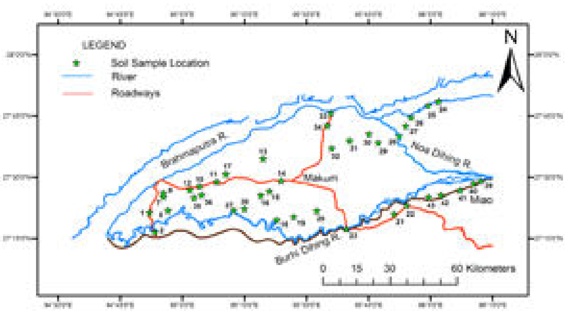

Fig. 1 : Map showing location of Soil Samples in the area

As we know, rainfall is considered to be the prime source of recharge to the ground water storage. The present area of study, being an integral part of the North Eastern India, receives sufficient amount of rainfall (M.A.R. 2075 mm) under the influence of South-West Monsoon. In order to get an idea of the pattern of seasonal variation of rainfall in the area, the mean monthly rainfall of six rain gauge stations have been used to prepare a graph (Fig. 2) showing the monthly distribution of rainfall. Rainfall is quite low in the months of November, December and January. Pre-monsoon showers are generally first experienced in the month of April, and from May onwards there is a sharp increase in the intensity of rainfall, with South-West Monsoon playing its dominant role during the period from June to September. July is the month receiving the highest monthly average rainfall of 352 mm. A substantial amount of this rainfall has the scope for positively contributing to the ground water storage in the shallow aquifer zone if the surface layer of soil allows easy infiltration to the rainwater. So, assessment of the hydrological parameters of soil is always considered to be an important aspect in any hydrogeologic investigation.

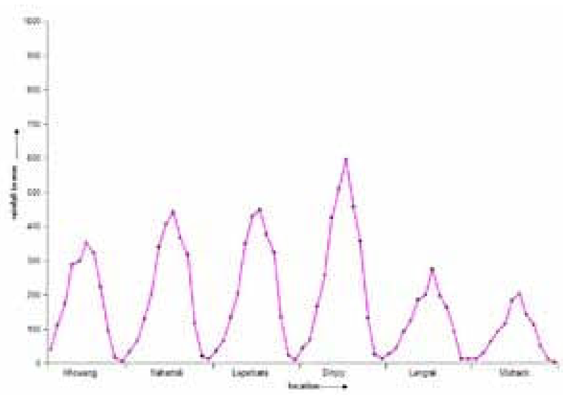

Fig.2: Distribution of monthly rainfall at different locations

Materials and Methods

Altogether 43 soil samples were collected from different locations of the area by making small pits of around 1.50 ft in depth. About 200 gm of fresh soil samples were collected from each of these pits by making a thin vertical slice extending from top to bottom. These samples were mechanically analyzed (sieving) in the laboratory in order to determine their textural characteristics (Table 1) and relevant hydrological parameters (Table 2). Sieving and pipetting were done by following standard procedure (Carver, 1971). Soil texture is an important physical characteristic of soil which may be defined as the degree of coarseness or fineness of soils resulting from the relative proportions of the particle size fractions- sand, silt and clay (Goswami *et al*., 1999). Textural class of soil has been determined by following standard methods (USDA, after Fitzpatrick, 1971). The textural nomenclature of the soils of the area has been done following the triangular diagram method as devised by the U.S Department of Agriculture (Fig. 3). On that basis, soils of the area are classed as ‘Sand’. The term ‘texture’ also includes the shape and size, arrangement and packing of particles which give the idea of **porosity** of soil. **Permeability** is controlled not only by the void space but also by the size of the individual voids and their connecting passages. Coarseness of grains, denoted by **Effective Size** (d_{10}), is responsible for presence of larger voids, and thus has an important control on porosity and permeability. Again, a good porous formation may not be permeable as well. Therefore, the distribution of particle size of a soil is of fundamental importance in determining its porosity and permeability. **Sorting** is an important term frequently used in soil textural study, which gives an idea about the distribution of particle size of a soil. The degree of sorting and uniformity of particle size distribution of soils can be studied by means of '**Sorting coefficient**' and '**Uniformity coefficient**'. Smaller values of these parameters normally indicate better sorting. Other things remaining equal, poorly sorted sediments will have lower values of porosity and permeability (Davis and DeWiest, 1966). Representative grain size analysis curves are presented in Fig. 4.

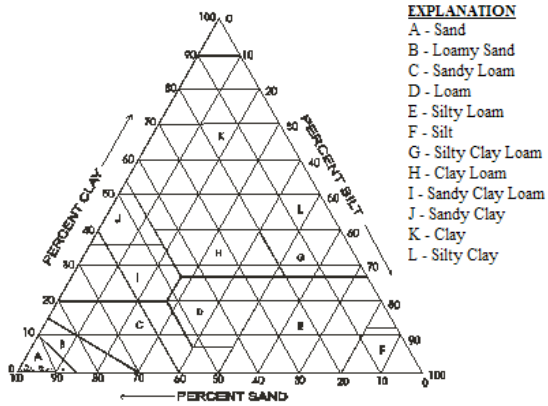

Fig. 3: Triangle of soil texture describing textural class of a representative soil samples of the area (after U.S. D.A.)

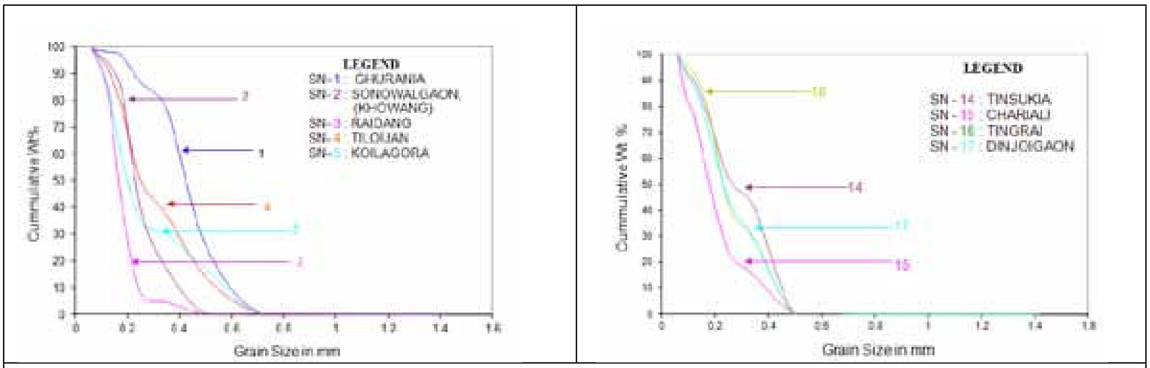

Fig. 4 : Grain size analysis curves of a few representative soil samples of the area

Table 1 : Textural analysis of a few representative soil samples

Sample no	Sand (%)	Silt (%)	Clay (%)	Soil Type
1	99.42	0.08	0.50	Sand
2	96.83	2.67	0.50	Sand
3	94.08	4.92	1.00	Sand
4	96.96	0.53	2.51	Sand
5	96.15	0.84	3.01	Sand
10	96.61	2.29	1.10	Sand
11	98.93	0.57	0.50	Sand
12	98.04	1.46	0.50	Sand
20	93.99	5.51	0.50	Sand
21	97.10	2.40	0.50	Sand
22	96.91	2.59	0.50	Sand
23	97.43	1.57	1.00	Sand
24	89.62	9.78	0.60	Sand
25	98.06	1.44	0.50	Sand
31	87.71	11.79	0.50	Sand
32	92.81	5.69	1.50	Sand
33	98.90	0.60	0.50	Sand
34	98.51	0.99	0.50	Sand
35	94.81	4.19	1.00	Sand

39	94.43	5.07	0.50	Sand
40	99.19	0.31	0.50	Sand
41	93.65	5.35	1.00	Sand
42	96.91	2.09	1.00	Sand
43	96.94	2.56	0.50	Sand

Table 2 : Hydrological properties of a few representative soil samples

S. NO	LOCATION	EFFECTIVE SIZE (mm) d_{10}	UNIFIRMITY COEFFICIENT $C_u = d_{60}/d_{10}$	PERMIABILITY K = cd_{10}^2	SORTING CO-EFFICIENT $S_c = \sqrt{(d_{75}/d_{25})}$
1	Ghurania	0.158	2.15	2.50	1.18
2	Khowang	0.150	1.20	2.25	1.16
3	Raidang	0.070	1.86	0.49	1.21
4	Tiloijan	0.092	2.39	0.85	1.55
5	Koilagora	0.078	1.83	0.61	1.79
6	Changmai Goriagaon	0.128	2.27	1.64	1.40
7	Thakurthan	0.065	3.08	0.42	1.84
8	Jokai Kowargaon	0.112	2.86	1.25	1.66
9	Khanikar	0.055	3.09	0.30	1.73
10	Dikam	0.095	2.74	0.90	1.51
25	Momong	0.15	1.20	2.258	1.25
26	Lathau	0.140	1.71	1.96	1.39
27	Nalam	0.090	0.39	0.81	1.49
28	Namsai	0.067	1.94	0.45	1.65
29	Nabajyoti	0.080	1.75	0.64	1.08
30	Amguri,Patani	0.132	1.50	1.74	1.24
34	Haru dhadum	0.130	2.08	1.69	1.37
35	Romai	0.080	1.81	0.64	1.31
39	Miao	0.080	2.13	0.64	1.41
40	Tibatan Sattlement	0.150	2.20	2.25	1.32
41	Old Champu	0.075	2.13	0.56	1.33
42	New Lisan	0.100	2.60	1.00	1.46
43	Ongman	0.095	1.58	0.90	1.240

Results and Discussion

- **Effective Size (d_{10}):** The effective size (Hazen, 1892) of the soil samples have been determined from the size analysis curves (Fig. 4) prepared from the mechanical analysis data of the soil samples. Effective size is that size (in the sand analysis curve) at which 10% of the material is finer and the remaining 90% is coarser. This parameter indicates the overall coarseness of a sand/ soil sample. It has direct influence on porosity and may also affect the permeability as well, subject to fulfilment of other conditions.

- **Sorting coefficient (S_c):** The sorting coefficient (Walton, 1970), which indicates the degree of sorting of soil, is the square root of the quotient of the 25 percentile size ($_{d75}$, i.e. the size at which 75% material is finer) and the 75 percentile size ($_{d25}$, i.e. the size at which 25% material is finer). These sizes can again be read from the cumulative curves.

- **Uniformity coefficient (C_u):** The uniformity coefficient (Hazen, 1892), which gives an idea of the grading or particle size distribution of the soil, is the quotient of the 40 percentile size (d_{60}) and the 90 percentile size (d_{10}) i.e. the effective size. It is the average slope of the curve between the 90 percentile and the 40 percentile particle sizes. Lower values of uniformity coefficient (C_u < 2.0) normally indicate more uniform material (Raghunath, 1982, Karanth, 1987).

- **Permeability:** In the present study, an attempt has been made to calculate permeability from sand analysis curves by using the following formula suggested by Hazen (1911) and quoted by Cedergren (1977) : **K (mm/sec) = c d_{10}^2**. Here, d_{10} is the effective size in cm and the value of 'c' varies from about 90 to 100. A value of 100 is often used for 'c', which is also adopted for the present study.

The values of effective size, sorting coefficient, uniformity coefficient and permeability calculated for all the soil samples have been presented in the Table 2. The summarized statement about these parameters is given below:

i) Soil type : 'SAND'

ii) Sand% : 85.36 - 99.42
Silt % : 0.08 – 13.63
Clay % : 0.50 – 3.02

iii) Effective size (d_{10}) : 0.050 mm – 0.158 mm
Uniformity Coeff, Cu (d_{60}/d_{10}): 1.20 – 3.09
Sorting Coefficient ($\sqrt{d_{75}/d_{25}}$) : 1.07 – 1.90
Permeability (cd_{10}^2) : 0.25 – 3.24 mm/sec

- **Infiltration characteristics of soils:** Soils of the area are of "Sand" type containing small amounts of silt and clay. Soils are mostly of uniform nature (moderately to uniformly graded) and well sorted to moderately well sorted, thus pointing towards overall good infiltrating characteristics. Good amount of annual rainfall bestowed by the South-West Monsoon and overall all low topographic relief of the area are the other two favourable factors influencing fair amount of rainfall infiltration into the shallow aquifer zones.Unless otherwise hindered by pavements, roofs of houses in urban areas, thick vegetations or relatively greater local topographic slopes, the area should facilitate infiltration of rainwater ensuring a fair amount of recharge to the ground water storage.

Conclusions

Presence of higher percentage of sand (85.36% to 99.42%) compared to silt and clay, overall larger effective size (0.050 mm to 0.158 mm), relatively smaller values of uniformity coefficient (1.20 to 3.90) and sorting coefficient (1.07 to 1.90), and better permeability (up to 3.24 mm/sec) indicative of favourable hydrologic characteristics should attribute better infiltrating capability to soils of the area. Soils are mostly of uniform nature (moderately to uniformly graded) and well sorted to moderately well sorted, thus pointing towards overall good inherent infiltrating characteristics. Good amount of annual rainfall bestowed by the South-West Monsoon and overall all low topographic relief of the area are the other favourable factors in this regard. So the area should facilitate infiltration of rainwater ensuring a fair amount of recharge to the ground water storage in the shallow aquifer zones.

REFERENCES

1. Carver, R. E., (1971): Procedures in Sedimentary Petrology. John Wiley & Sons Inc., pp 79-86. | 2. Cedergren, H. R., (1977): Seepage, Drainage and Flownets. 2nd Ed., John Wiley & Sons Inc., New York, 534 p. | 3. Davis, S. N. and DeWiest R. J. M. (1966): Hydrogeology, john Wiley & Sons, New York, 463 p. | 4. Fitzpatrick, E. A. (1971): Pedology – A Scientific Approach to Soil Science. Oliver & Boyd, Edinburg, 306 p. | 5. Hazen, A. (1892): Some Physical Properties of Sands and Gravels. Mass. State Board Health, 24th Annual Report. | 6. Goswami, U., Patgiri, A. D. and Sarma, J. N., (1999): Hydrological properties of soil from textural analysis; a case study of Lower Subansiri basin, Assam. Jour. Ind. Asso. Sed., V -18, No. 2, pp. 261-269. | 7. Karanth, K. R. (1987): Ground Water Assessment, Development and Management, Tata-Mc Graw-Hill Pub. Co. Ltd., New Delhi, 720 p. | 8. Ragunath, H. M., (1987): Groundwater (2nd Ed), Wiley Eastern Ltd. Delhi, India, 563 p. | 9. Walton, W. C., (1970): Ground Water Resources Evaluation, Mc Graw-Hill Book Co., New York. 664 P.