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Feasibility Study of Filter material for Subsurface Drainage System: Kalipatnam Case Study

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ABSTRACT

Filter material requirement for installation of subsurface system of Kalipatnam pilot area was assessed based on the soil texture at drain depth, soil SAR, ground and irrigation water quality. Textural analysis data at the sampling points were interpreted with the help of textural class, particle size distribution curve, per cent clay, clay/silt ratio and Surfer 7.0 map for clay%. Based on the results, filter material is required for installation of subsurface system and out of the tested prediction criteria for requirement of filter material clay % mapping, clay%, textural class, , particle size distribution curve are giving good indication of filter material whereas auger hole is over estimating for these soils. Clay/silt ratio criteria of 0.5 are not fitting for these soils. Surfer 7.0 mapping of percent clay at drain depth is giving best estimate out of the tested criteria.

Key words*:* Auger hole, Clay/silt ratio, Filter material,Per cent clay, Texture class.

Water logging and soil salinity are the twin problems for lower yields in canal commands of Godavari Western Delta. A.P., India. To alleviate these problems sub surface drainage system would be a viable option. Installation of subsurface drainage system creates a drainage force of water flowing towards a drain. Along with this drag force soil particles may be carried into the drain from all sides called as drain pipe siltation resulting due to particle invasion of cohesion less soil or suspended materials through soil pores or cracks and voids. This process can never be prevented completely but it can be counteracted by installing a filter material around the drain pipe. The need of envelope material around drain pipes depends on the physical and chemical properties of the soil, on the chemical composition of the water to be drained and on the conditions under which the pipes are installed (FAO,2005). Attempts have been made to define and identify soils that are prone to cause mineral clogging of drain pipes. Although many soil types have been identified as being susceptable to sedimentation than others, sound criteria as to whether drains require a filter material or not have not yet been established. There are existing criteria, usually based on local experience and only valid for regions where they have been established like soil textural class at drain depth, particle size distribution curves, auger holes, clay/silt ratio, plasticity index, coefficient of uniformity, soil salinity, soil sodicity, irrigation and ground water quality etc.

In the present study some of the possible filter material prediction criteria were estimated to assess the requirement of filter material for Kalipatnam pilot area, A.P, India.

MATERIAL AND METHODS

Study Area: Kalipatnam pilot area (16°23'N, 81°32'E) is located in Godavari Western Delta near east cost of Peninsular India. This area comprise of alluvial, waterlogged (Fig 1) and saline sodic soils(Table 1)adjacent to salt stream which joins the sea at a distance of 9 km .

Auger holes were made at 17 locations covering entire study area of 36 ha. Soil samples at drain depth (60-100cm) were collected after duly testing whether the auger holes collapsed (x) or not (+) and analysed for textural analysis (Piper,1966). EC and SAR of saturated soil extract and ground water at drain depth were estimated (Table 4) (Richards, 1968). Textural class of the soil was estimated by textural class (FAO, 1990) (Fig 2 & Table 2) and filter material requirement for the respective textural classes were estimated (Table 3) by using the criteria outlined by Drainage fact sheet of British Columbia (2000). Surfer maps for per cent clay was prepared using surfer 7.0 package (Figure 3).

RESULTS AND DISCUSSION

a) Textural class: Study area textural constituents ranged as clay 5 to 56 per cent, silt 1 to 28 per cent and sand 22 to 94 per cent (Table 2, Fig 2). The soils are lying in seven different textural classes (clay-4, sandy clay-2, clay loam-1, sandy loam-4, loamy sand-2, sandy clay loam-4 and sand-3). Based on the classification given for filter

Figure1. Ground water table fluctuations of study area (May 2005 to May 2006)

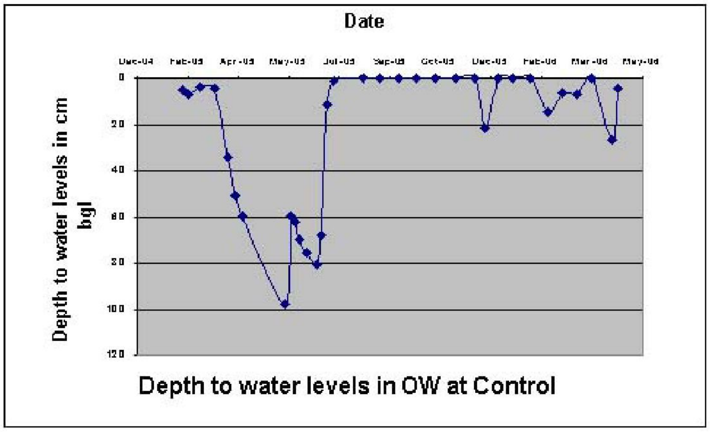


Table 1. Soil properties of Kalipatnam Drainage Pilot Area

S.NO	Parameter	Range		Average
		Minimum	Maximum	
1	pH	6.09	8.32	7.20
2	EC (dSm^{-1})	5.9	44.8	15.7
3	Ca^{++}($me\ L^{-1}$)	4.5	38.5	12.6
4	Mg^{++} ($me\ L^{-1}$)	2.75	90.0	26.0
5	Na^{+} ($me\ L^{-1}$)	55.1	404.0	118.9
6	K^{+} ($me\ L^{-1}$)	1.16	7.93	2.79
7	SAR	17.18	89.18	32.23
8	ESP(%)	19.40	56.58	30.94

material requirement of different classes (Table 4) six samples (clay-4, sandy clay-2) do not require filter material and rest (10 number) require filter material (clay loam class not given in the classification). Results indicate that there is wide variation in the texture of the soil and as majority of soils are lying in the filter material required classes, filter material is recommended for these soils.

b) Clay per cent: Clay per cent at drain depth is important criteria for predicting filter material requirement. Clay percent of 30 is being taken as criteria else where in the world. But RAJAD Project staff (1995) drainage experience revealed that wherever soils are sodic, lower limit of clay per cent (30%) is increase to 40 per cent . In the present study, soils are saline sodic (Table 1) and hence 40 percent clay may be taken as criteria. Textural analysis data indicates that out of 17 samples, in 4 samples (23%) clay per cent is more than 40 per cent which do not require any filter material, where as in 6 samples (35%) are lying in the safe zone when more than 30 per cent is taken as criteria. Though the mere clay per cent is not giving the spatial distribution of soil, this can be used as good criteria. From the results it is inferred that filter material is required for these soils

c) Clay / silt percent: This is important for predicting the requirement of filter material. According to Dieleman and Trafford (1976), the risk of mineral clogging decreases rapidly when this ratio exceeds 0.5. In the present study, clay/silt percent ranged from 1.2 to 5.7 (Table 2), which are considerably higher than the critical ratio of 0.5. Based on this filter material is not required for these soils. These results are not in agreement with that of other criteria. Hence, Dieleman and Trafford's (1976) critical clay/ silt ratio of 0.5 is not fitting well to these soils.

d) Auger hole: Auger holes intended for determination of the hydraulic conductivity is simple field observation, which yields useful information to predict the requirement of filter material for lateral drains of subsurface drainage system. Out of tested 17 sample points in 13 points (76%) auger holes are collapsed at the time of sampling (Table 2) and these points show low soil consistence, for which filter material is required when installation of subsurface drainage system. In this method, wherever sandy soil is over laid auger holes are getting collapsed. Hence this method over estimates filter material requirement in this of soil conditions where surface / subsurface soil above the drain depth are sandy in nature.

e) Soil chemical properties: Dispersion problems are generally more severe where ESP/SAR values are greater. Dispersion material may be transported by ground water and will enter the drain pipe. In India, the clay content of soils, for which no filter material around drains are required, increased from 30 to 40 per cent for soils with SAR exceeding 13 (Rajad Project Staff, 1995). Soils having an SAR greater than 15 per cent will not disperse as long as the salt concentration in the soil solution decreases, due to leaching by rain or irrigation water, dispersion problems may arise (Smedema and Rycroft,

Table 2. Drain depth soil textural class, soil and water EC and SAR at different locations

S.NO	Location	Textural analysis(%)			Textural class	Filter	Clay (<40%)	Clay (<30%)	Soil		Ground water		Clay/ silt	Auger hole		
		Clay	Silt	Sand					EC	SAR	EC	SAR				
1	P1-1m	56	22	22	Clay	NO	No	NO	16.1	32.0	32.6	4.0	2.5	YES	+	NO
2	S2(00.6-1m)	16	9	75	Sandy loam	YES	YES	YES	19.6	27.6	23.9	4.1	1.8	YES	x	YES
3	P3-1m	42	17	41	Sandy clay	NO	NO	NO	8.3	22.5	29.6	4.8	2.5	YES	+	NO
4	S3-(0.6-1m)	22	9	69	Sandy clay loam	NO	YES	YES	21.2	30.9	49.1	5.1	2.4	YES	x	YES
5	S1-(0.6-1m)	30	13	56	Sandy clay loam	NO	YES	NO	18.9	28.9	46.3	5.3	2.3	YES	x	YES
6	P2-1m	12	7	81	Loamy sand	YES	YES	YES	11.5	25.1	28.6	4.9	1.7	YES	x	YES
7	G1(0.6-1m)	15	8	77	Sandy loam	YES	YES	YES	15.2	27.6	25.3	4.0	1.9	YES	x	YES
8	G10(0.6-1m)	55	20	25	Clay	NO	NO	NO	16.6	32.4	35.7	4.3	2.7	YES	+	NO
9	G23(0.6-1m)	15	6	79	Loamy sand	YES	YES	YES	13.3	35.6	36.4	4.2	2.5	YES	x	YES
10	G25(0.6-1m)	5	4	91	Sand	YES	YES	YES	22.6	31.1	30.5	4.8	1.2	YES	x	YES
11	G28(0.6-1m)	5	1	94	Sand	YES	YES	YES	15.0	28.9	22.3	4.5	5.0	YES	x	YES
12	G30(0.6-1m)	9	6	85	Sand	YES	YES	YES	11.6	29.5	26.2	4.1	1.5	YES	x	YES
13	G34(0.6-1m)	37	28	35	Clay loam	-	YES	NO	18.4	27.1	34.8	5.1	1.3	YES	x	YES
14	G37(0.6-1m)	27	6	67	Sandy clay loam	NO	YES	YES	18.4	28.4	40.5	5.6	4.5	YES	x	YES
15	G40(0.6-1m)	23	4	73	Sandy clay loam	NO	YES	YES	25.9	30.2	62.1	5.7	5.7	YES	x	YES
16	G42(0.6-1m)	45	10	45	Sandy clay	NO	No	NO	7.3	23.5	22.7	5.4	4.5	YES	+	No
17	G46(0.6-1m)	15	4	81	Sandy loam	YES	YES	YES	24.2	29.1	25.9	4.2	3.7	YES	x	YES

Figure 2. Textural Classes (FAO, 1990)

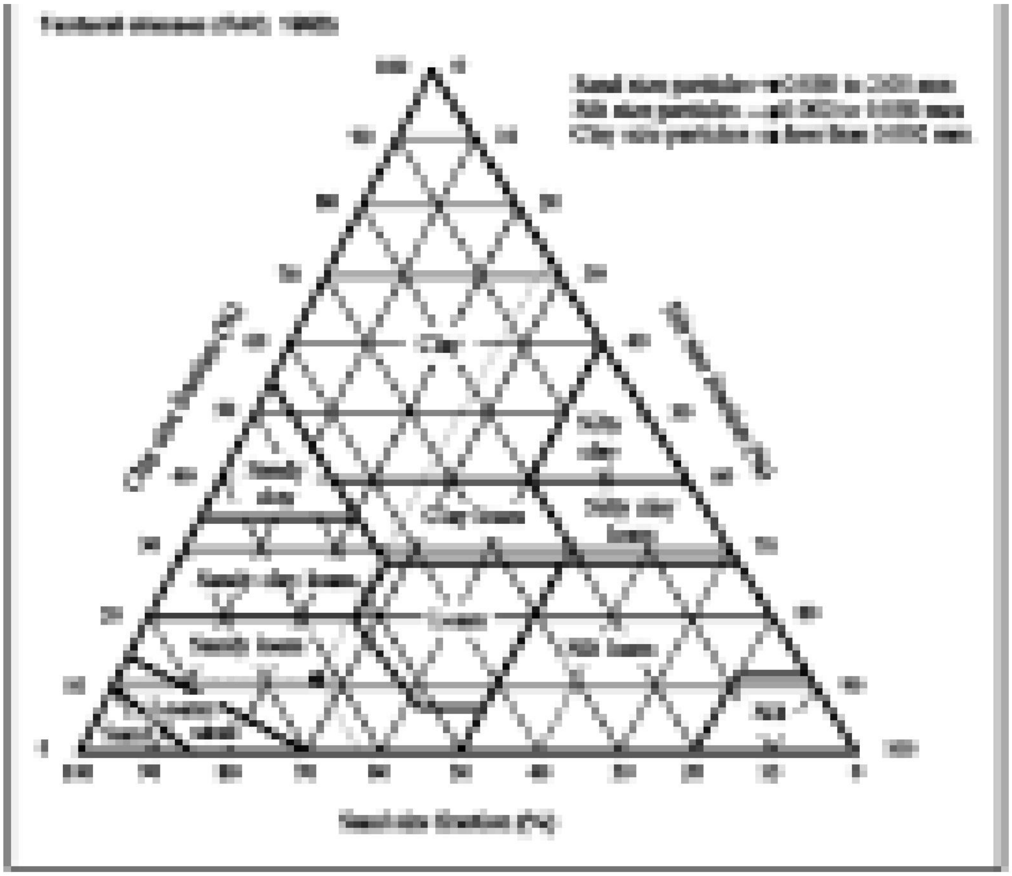


Table 3. Soil Texture - Drain Filter Recommendations

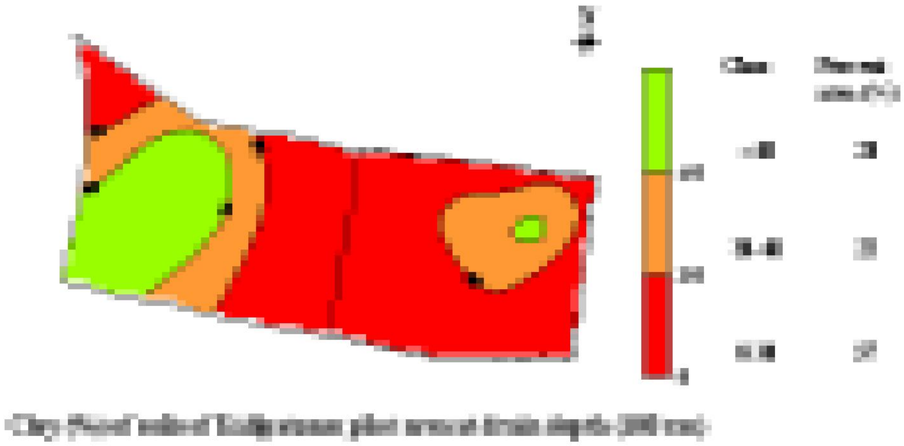
Soil Texture	Envelope or Filter recommendations	Degree of Urgency
Gravel	None	-
Gravelly coarse sand	None	-
Very coarse sand	None	-
Gravelly fine sand	Filter	Moderate
Medium sand	Filter	High
Fine sand	Filter	VeryHigh
Loamy Sand	Filter	High
Sandy loam	Filter	Moderate
Loam	Filter	Low
Silt	Filter	Moderate
Silty clay laom	None	-
Sandy clay	None	-
Silty clay	Envelope	Moderate
Clay	Envelope	Moderate
Peat	None	-

1983). In the present study, ECe and SAR values ranged from 7.3 to 25.9 dS/m and 22.5 to 35.6, respectively (Table 2), hence filter material is recommended for this soil.

f) Ground water quality: also followed the same trend as that of soil SAR (Table 2). In addition to this irrigation water quality is good (0.30dS/m). Irrigation with water of low salinity will decrease soil stability if the salt concentration of the soil solution is substantial.

g**) Clay per cent map:** Percent clay surfer 7.0 maps of the study area at drain depth was prepared (Fig 3) taking three classes (<30,

Figure 3. Clay per cent at drain depth in pilot area



30-40, >40%) into consideration of RAJAD experience as discussed earlier. From the surfer map about 70 per cent of area is lying with clay content of <30 per cent hence we can recommend filter material. These maps giving insight about spatial distribution of soil texture at drain depth and hence more useful for design of sub surface system.

Conclusions:

In all the tested criteria, majority of samples/ area warrants the requirement of filter material for installation of subsurface drainage system in these soils. Of the tested criteria, clay per cent at drain depth mapping gives good indication of filter material requirement in addition to spatial distribution of soil heterogeneity. Auger holes data though very simple and useful but meeting to the some extent only. Clay/ silt ratio is not fitting well to these soils, critical valued need to be increased for these soils.

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