IMPACT OF LIGNITE MINE DRAINAGE ON AN IRRIGATED COMMAND AREA – A CASE STUDY

Presented by

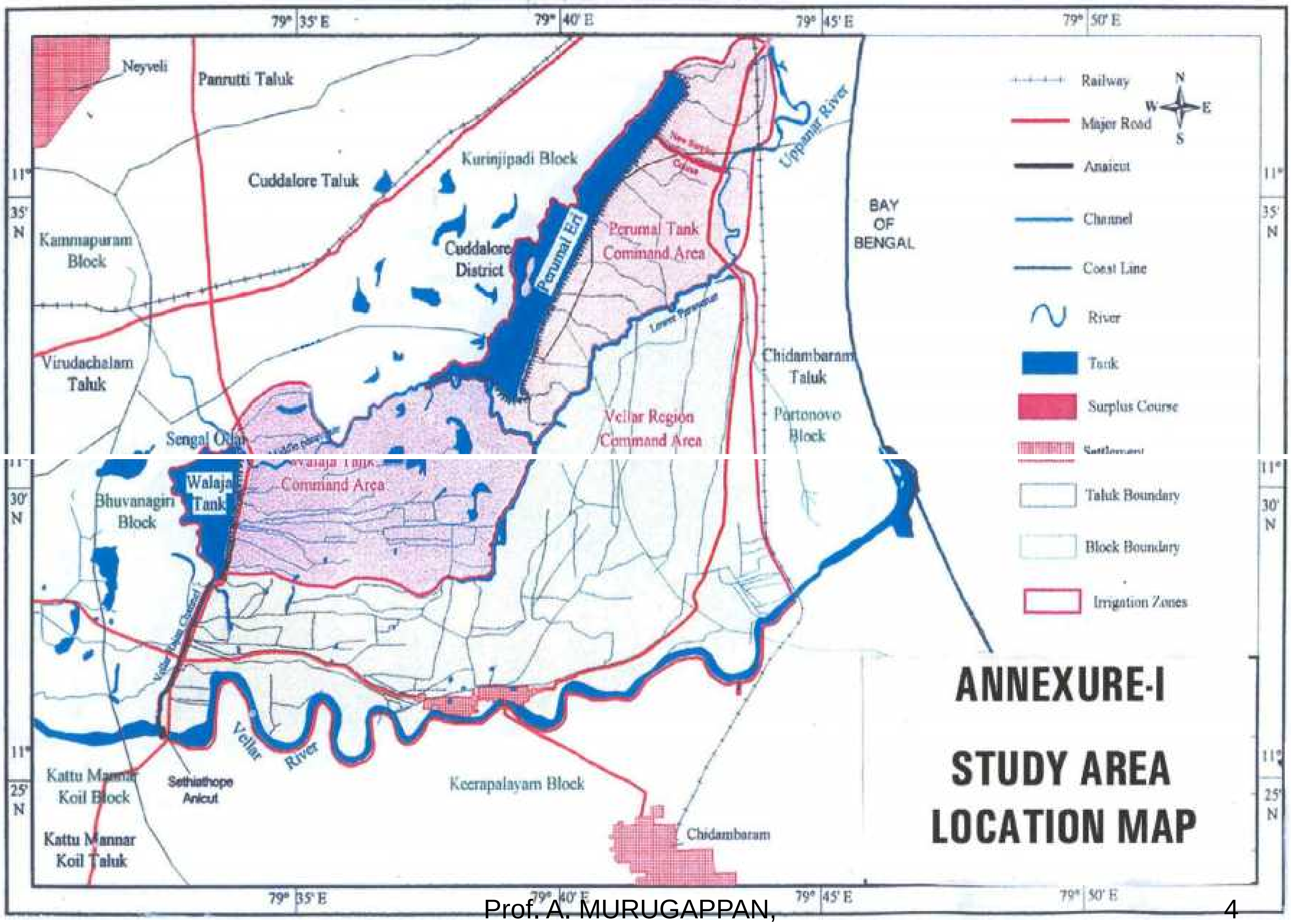
Prof. Dr. A. MURUGAPPAN,
Professor of Civil Engineering,
Faculty of Engineering & Technology
ANNAMALAI UNIVERSITY
ANNAMALAINAGAR - 608 002
TAMILNADU
E-mail: profam@gmail.com

Scope and Objectives of the Study

- Assessing the status of quality of surface waters released from the Walajah Tank System for irrigation in the respective commands, assessing the present status of soil properties in the command areas of the Walajah Tank system and Perumal Tank System and their impact on growth and yield of crops grown

- This study gains significance in light of the concerns of the water users in the commands of Walajah Tank, in particular, that the yields of crops have decreased in the recent years. The commands of Walajah Tank and Perumal Tank receive water continuously from the Neyveli Mine Drainage.

- The mine drainage consists of water pumped out from Mines I & II and water drained from fly ash ponds.
- The irrigation water, therefore, is very much likely to contain constituents of coal dust and fly ash.
- Therefore, it becomes imperative to study the possibilities of the constituents in irrigation waters of Walajah Tank system influencing or affecting the growth of crops grown.


79° 35' E
79° 40' E
79° 45' E
79° 50' E
Neyveli
Panrutti Taluk
Kurinjipadi Block
Cuddalore Taluk
Kammapuram Block
Cuddalore District
Perumal Eri
Perumal Tank Command Area
Uppanar River
BAY OF BENGAL
Virudachalam Taluk
Chidambaram Taluk
Vellar Region Command Area
Portonovo Block
Sengal Odai
Walaja Tank
Walaja Tank Command Area
Bhuvanagiri Block
Vellar River
Kattu Mannar Koil Block
Sethiathope Anicut
Keerapalayam Block
Chidambaram
Kattu Mannar Koil Taluk
Railway
Major Road
Anaicut
Channel
Coast Line
River
Tank
Surplus Course
Settlement
Taluk Boundary
Block Boundary
Irrigation Zones
N
S
E
W
11° 35' N
11° 30' N
11° 25' N
ANNEXURE-I
STUDY AREA LOCATION MAP

STUDY AREA

- The Walajah Tank irrigation system and Perumal Tank irrigation system form part of the Sethiathope Project. These are located on the left bank of the Vellar River, in the Cuddalore District, bordered on the east by coastal sand dunes.

- The climate of the area is monsoon type with an average annual rainfall of 1284 mm mostly during the North-East monsoon period of October-December.

- As the study area is located in the flood plain of the Vellar River, it suffers chronically from a shortage of water before September and from frequent floods during November-December either by the Vellar or by the Paravanar river.

- Paravanar river is a major drain crossing the area from West to North-East.

❖Thanks to the continuous supply of water from the Neyveli mine drainage, the commands of both Walajah and Perumal Tank Systems could be irrigated throughout the year.

❖Walajah Tank Irrigation System

❖Walajah Tank has a very limited storage capacity but a relatively huge command area.

❖The original capacity of 2.57 million cubic metres has shrunk to a reported 1.66 million cubic metres due to human encroachment.

❖The tank collects runoff from its catchment during the rainy season, receives inflow from Neyveli mines throughout the year and receives surplus waters from the Vellar Rajan Canal.

Hydraulic Particulars of Walajah Tank

S.No.	Details	
1	F.T.L.	37.50 feet
2	M.S.L.	42.00 feet
3	T.B.L.	49.00 feet
4	Capacity	90.72 Mcft
5	Command Area	11292 acres
6	Catchment area	74.844 sq. miles (2.57 Mcum)
7	Water Spread Area	
8	Maximum Width of Tank	1 km
9	Length of bund	4.91 km
10	Width of bund	2.1 km
11	No. of sluices/channels	12
12	Length of channels (total)	22.31 km
13	Command Area of channels (total)	11292 acres
14	No. of PWD channels	2
15	Length of PWD channels (total)	13.31 km
16	Command area of PWD channels (total)	5788 acres
17	No. of Revenue channels	10
18	Length of Revenue channels (total)	45.31 km
19	Command area of Revenue channels (total)	5504 acres
20.	Number of villages served	22

Hydraulic Particulars of Perumal Tank

S.No.	Details	
1	F.T.L.	17.86 feet
2	M.S.L.	22.56 feet
3	T.B.L.	27.86 feet
4	Capacity	574 Mcft
5	Command Area	6503 acres
6	Catchment area	216 sq. miles
7	Water Spread Area	151.60 Million sq.ft
8	Maximum Width of Tank	
9	Length of bund	16 km
10	Width of bund	5.49 km
11	No. of sluices/channels	11
12	Length of channels (total)	49.91 km
13	Command Area of channels (total)	6503 acres
14	No. of PWD channels	Nil
15	Length of PWD channels (total)	Nil
16	Command area of PWD channels (total)	Nil
17	No. of Revenue channels	9
18	Length of Revenue channels (total)	49.91 km
19	Command area of Revenue channels (total)	6503 acres
20.	No. of villages served	20

- The tank is protected against flooding by two weirs on its southern flank, near the point where the Paravanar river joins it.

- Through these weirs, surplus waters are discharged into the Lower Paravanar river.

- The tank receives runoff from its catchment and water surpluses from Walajah Tank through the Middle Paravanar.

- Water is released almost throughout the year through the surplus arrangement from Walajah tank to Perumal tank due to the continuous inflow to Walajah Tank from Neyveli Mine Drainage.

Cropping Pattern

❖Paddy is the principal crop grown in the commands of both Walajah and Perumal Tank Systems.

❖As the ryots of the commands of Walajah and Perumal Tank systems are blessed with continuous availability of water in the form of mine drainage from Neyveli, they raise two crops.

- **In the tank irrigated commands, the first crop of paddy is usually a short term variety grown in June/July to September/October.**

- **The second crop in the commands of Walajah Tank is a medium variety paddy crop grown during September/October to January/February, while the second crop in the commands of Perumal Tank is also a medium variety of paddy but grown during December-January to March/April. As the water availability is scarce during the South-West monsoon period, the first crop covers only about one-third of the command area.**

- **The second crop which is grown during the North-East monsoon period covers about 90% of the command area. Annexure-II shows the land use pattern in the Sethiathope Project in which the study area is present.**

Guidelines for Interpretation of Water Quality for Irrigation

Potential Irrigation Problem	Units	Degree of restriction on use		
		None	Slight to Moderate	Severe
Salinity (affects crop water availability)				
EC	dS/m	< 0.7	0.7 – 3.0	> 3.0
(or)				
TDS	mg/l	< 450	450 - 2000	> 2000
Infiltration (affects infiltration rate of water into the soil; evaluated using EC and SAR together)				
SAR = 0 – 3 and **EC** =		> 0.7	0.7 – 0.2	< 0.2
SAR = 3 – 6 and **EC** =		> 1.2	1.2 – 0.3	< 0.3
SAR = 6 –12 and **EC** =		> 1.9	1.9 – 0.5	< 0.5
SAR=12 – 20 and **EC** =		> 2.9	2.9 – 1.3	< 1.3
SAR = 20-40 and **EC** =		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity (affects sensitive crops)				
Sodium (Na) (for surface irrigation)				
SAR		< 3.0	3 -9	> 9.0
Chloride (Cl) (for surface irrigation)				
	me/l	< 4.0	4 - 10	> 10.0
Boron	mg/l	< 0.7	0.7 –3.0	> 3.0
Trace Elements	Please See **Table 3.3**			
Miscellaneous Effects (affects susceptible crops)				
Nitrogen (NO_3 – N)				
Bicarbonate (HCO_3) (Overhead Sprinkling only)	mg/l	< 5	5 - 30	> 30
pH		Normal Range 6.5 – 8.4		

Laboratory Determinations Needed to Evaluate Common Irrigation Water Quality Problems

Water Parameter	Symbol	Unit	Usual Range in Irrigation Water
SALINITY			
Salt Content			
Electrical Conductivity	EC	dS/m	0 – 3
(or)			
Total dissolved solids	TDS	mg/l	0 – 2000
Cations and Anions			
Calcium	Ca^{++}	me/l	0 – 20
Magnesium	Mg^{++}	me/l	0 – 5
Sodium	Na^{++}	me/l	0 – 40
Potassium	K^{+}	mg/l	0 – 2
Carbonate	CO_3^{--}	me/l	0 – 0.1
Bicarbonate	HCO_3^{-}	me/l	0 – 10
Chloride	Cl^{-}	me/l	0 – 30
Sulphate	SO_4^{--}	me/l	0 – 20
MISCELLANEOUS			
Acid/Basicity	pH	1 - 14	6.0 – 8.5
Sodium Absorption Ratio	SAR		0 – 15
Boron	B	mg/l	0 – 2

Crop tolerance and Yield Potential of rice as influenced by Irrigation Water Salinity (EC_w) and Soil Salinity (EC_e)

Field Crop	**Yield Potential (in percent)**									
	100		**90**		**75**		**50**		**0**	
	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e
Rice	2.0	3.0	2.6	3.8	3.4	5.1	4.8	7.2	7.6	11.0

Classification of Irrigation Water Based on Electrical Conductivity

Class	Water Class	Electrical Conductivity (micromhos/cm)	Salinity hazard	Suitability for irrigation
C1	Excellent	Less than 250	Low	Suitable for irrigation of most crops and most soils with little danger of salinity development
C2	Good	250 - 750	Moderate	Can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown
C3	Moderate	750 - 2250	Medium high	Can be used on well drained soils growing salt tolerant crops
C4	Not satisfactory	2250 - 4000	High	Can be used on soils with restricted drainage. Even with adequate drainage, special management for salinity is required and plants with good salt tolerance are selected
C5	Generally Unfit	4000 - 6000	Very high	Not suitable for irrigation under most conditions, but may possibly used on soils with high drainage and sufficient water supply. Only high salt tolerant crops can be grown

Classification of Irrigation Water Based on Sodium Absorption Ratio

Class	Water Class	SAR Value	Type of Water	Suitability for Irrigation
S1	Excellent	0 - 10	Low sodium water	Suitable for all soils and all crops except those which are highly sensitive to sodium
S2	Good	10 - 18	Medium sodium water	May be used on coarse textured or organic permeable soils. Addition of gypsum either to water or soil is required for use on fine textured soils; otherwise, it is harmful as it renders the soil less permeable, plastic and sticky when wet and tendency to crusting on drying. The soils tend towards alkaline because of increase in pH value
S3	Fair	18 - 26	High sodium water	May be used provided gypsum is added, and good drainage and high leaching is provided. It may cause considerable sodium damage to most soils but it can be applied under certain very restricted conditions
S4	Poor	Over 26	Very high sodium water	Generally not suitable except perhaps at low salinity under very restricted conditions.

IRRIGATION WATER QUALITY - SURFACE WATERS OF WALAJAH TANK AND PERUMAL TANK SYSTEMS

- ✓ **The quality of irrigation water samples drawn from heads, middle and tail reaches of the various channels forming part of the Walajah Tank Command.**

- ✓ **The quality of irrigation water samples drawn from various reaches of the 11 irrigation channels taking off from Perumal Tank System.**

- ✓ **Electrical conductivity of water samples drawn from various reaches of different channels of Walajah Tank System showed a variation from a low value of 1.016 dS/m to a high value of 2.200 dS/m.**

- ✓ **For most of the water samples, the electrical conductivity was found to be in the narrow range of 1.500 to 1.800 dS/m.**

- ✓ **The electrical conductivity of water samples drawn from different reaches of various channels taking off from Perumal Tank System ranged between a low of 0.526 dS/m and a high of 1.531 dS/m.**

- ✓ **The water samples drawn from six of the eleven Channels were within 0.750 dS/m.**

✓Comparatively speaking, the EC values of waters of Perumal Tank System are less than the waters of Walajah Tank System. Both tanks almost continuously receive the Neyveli Mine Drainage with Walajah Tank located on the upstream of Perumal Tank.

✓ As the storage capacity and catchment area of Perumal tank are much higher (about 6 times and 3 times respectively) than that of the Walajah Tank, whenever rainfall occurs in the catchment of Perumal tank it augments the local inflow to the tank in addition to the Neyveli drainage water.

- ✓ This rain water dilutes the concentration of total dissolved salts present in Neyveli Mine Drainage resulting in lesser Electrical conductivity of irrigation waters of Perumal Tank.
- ✓ Because of lesser storage capacity and lesser catchment area, the inflow from the local catchment of Walajah Tank during periods of rainfall does not add to the storage much and has less diluting effect on the waters of Neyveli Mine Drainage. Therefore, the electrical conductivity of irrigation waters of Walajah Tank System are much higher.
- ✓ The SAR values of water samples drawn from irrigation channels of Walajah Tank system fall in the range between a low of 1.650 to a high of 3.515. But, for most of the water samples, the SAR lies in a close range of 2.028 and 2.942
- ✓ For irrigation waters of Perumal Tank system, the SAR values lie in the range 1.696 to 3.249.

- ✓ **Comparatively speaking, in general, the SAR values of irrigation waters of Perumal Tank System are found to be lesser than those of Walajah Tank System.**
- ✓ **On the average, the SAR values of most of the water samples tested indicate SAR values lesser than 3.0 for both Walajah and Perumal Tank irrigation systems.**

✓As per the guidelines for interpretation of water quality for irrigation, for SAR between 0 to 3 and Electrical conductivity of water greater than 0.7 dS/m, there is no restriction on use of water for irrigation.

✓ As per the US Salinity diagram for irrigation water, in general, the irrigation water of Walajah Tank was categorized as Class C3-S1 (that is, Low sodium hazard and Medium-high salinity hazard).

✓ The quality of water of Walajah Tank for irrigation was under moderate category.

✓ In case of Perumal Tank System, the irrigation waters of two channels fell under the Class C2-S1 (that is, low sodium hazard and moderate salinity hazard).

✓ The quality of waters of these channels for irrigation was under good category.

✓ **The quality of irrigation waters of the other channels of Perumal Tank fell under the category C3-S1 (moderate quality).**

✓ **Hence, going by the above standards and considering also the crops grown in the commands of both Walajah and Perumal Tank irrigation systems, there is no problem of salinity and no problem of infiltration caused by SAR.**

✓ **But, the farmers of Walajah Tank System, in particular, say there has been reduction in the yields of rice crops grown in the command area in the past decade or so. Why?**

✓ **The following discussions will throw some light on this issue and bring out the possible reasons for the problem.**

✓it was observed that the turbidity of irrigation waters flowing in many of the channels of Walajah Tank System is high.

✓ The high turbidity of waters is attributed mainly to the colloidal suspended particles, mainly the coal dust from the Neyveli Mine Drainage.

✓ This aspect is strengthened by the high content of suspended solids in many of the water samples drawn from different locations in the channels.

✓ This reveals that the Walajah Tank is not functioning as an effective storage unit and merely acts as a receiving unit before conveying the mine drainage from it directly to the off-taking irrigation channels.

Deposits of Mine Particles D/S of Walajah Tank Surplus Area

✓No effective settling of drainage water takes place in the tank. This is basically due to the inadequate storage capacity of the Walajah Tank to allow effective settling of the suspended particles in waters received by it, particularly the mine drainage which is received continuously by the tank all throughout the year.

✓Further, presently, even the original storage capacity of the tank is not available due to sedimentation, weed growth and encroachments.

✓Simply, the mine waters drained to Walajah Tank simply flows in the form of a channel flow along a course nearer to the eastern bund of the tank before getting discharged through the various sluices.

✓Altogether, there is no storage at all in the Walajah Tank. Hence, Walajah Tank does not serve the primary function expected of a tank, that is, storage.

✓it was found that the turbidity of waters released through the channels of Perumal Tank system for irrigation is very less.

✓The analysis of water samples drawn from different reaches of different irrigation channels also revealed that the suspended solids are very less and could be practically ignored. That is, the higher available storage capacity of Perumal Tank is effective in trapping the suspended particles present in water.

✓What is the effect of these colloidal particles (including the micro particles due to coal wash present in mine drainage) on irrigated soils?

✓To identify the possible effects of these micro suspended particles, it necessitated the evaluation of fundamental physical properties of field soil samples namely, bulk density, particle size distribution and permeability.

PHYSICAL ANALYSIS OF SOIL SAMPLES

Optimum Bulk Density for maximum Plant Available Water and Field Range Bulk Densities for a Range of Textures

Soil	Optimum density (g/cm^3)	Field Density (under cultivation)	
		Range (g/cm^3)	Mean (g/cm^3)
Loamy sand	1.75	1.23 - 1.59	1.52
Sandy loam	1.50	1.05 - 1.72	1.34
Silt loam	1.40	No data	No data
Clay loam	1.20	0.94 - 1.57	1.30

Optimum Bulk Density is the bulk density where plant available water is maximum

- **Comparing the data Table, it is clear that for sandy soils with a low plant available water capacity that an increase in bulk density can be beneficial.**
- **However, on heavier soils the optimum bulk density seems to be lower than the bulk density of fields under cultivation and hence the problem is to keep the bulk density as low as possible.**
- **Thus an increase in bulk density in fine grained soils will lead to a decrease in the amount of macro pores thereby reducing plant available water at low suctions.**
- **At high suctions an increase in bulk density increases soil water retention (not plant available) and the net effect is reduction in plant available water.**

✱Although an increase in bulk density might improve water retention properties of certain soils, high densities are undesirable in all soils as root penetration resistance is increased which leads to limit growth and distribution and thus reducing water use efficiency.

✱It was observed that the bulk densities of almost all samples collected from the Walajah Tank command were high and more than the recommended permissible range for effective uptake of nutrients by the crops grown. In Perumal Tank command area, the bulk densities of soil samples were relatively lesser.

✱Relatively speaking, the bulk densities of most of the field samples of soil drawn from cultivated lands of Walajah Tank Command were higher than than those drawn from Perumal Tank Command.

✱Sieve analysis was also performed on undisturbed soil samples collected from the command in the head reaches of certain channels of Walajah Tank System, to determine the particle size distribution.

✱It was found that the content of clay in field soil samples drawn from cultivated lands of Walajah Tank Command was high.

✱**Considering the particle size distribution and the recommended range of field density, it is most likely that the higher bulk densities of soils will have a negative impact on growth of crops grown.**

- **Agronomists opine that the percolation process is favorable for the plant growth, as the water movement will keep oxygen content within the soil at a reasonable soil. Normal percolation rates are 1-3 mm/day on soils with high clay content.**
- **It was observed that the permeability of all soil samples were very less. This may hamper the growth of the crops grown in the study area.**

Assessment of the Overall Fertility Status of Soils in the Command Areas

↔ To delineate the extent of command areas of both Walajah and Perumal Tank systems by the NLC Mine Drainage, the most important soil properties namely, pH, EC, major nutrients N, P, K and micronutrient Zn were considered.

↔ **Observed higher levels of pH (pH > 7.5) and EC (EC > 1 dSm^{-1}) and deficient levels of major nutrients N, P and K and micronutrient Zn were considered as the main indicators for poor soil fertility and hence reduction in yield.**

↔ **In Perumal Tank command area, the percentage areas affected by alkalinity (pH > 7.5) and salinity (EC > 1 dSm^{-1}) was found to be very less compared to that of Walajah Tank command area.**

↔ **More than three-fourths of the command area in Walajah Tank command area has low N while only about one-half of the command area of Perumal Tank have low N. Therefore, the nitrogen availability in soils of Perumal Tank command area is a shade better than that of Walajah Tank command area.**

- ↔ **Nearly, more than 50% of the areas under the command of Walajah Tank show low Zn levels. While, in case of Perumal Tank command area, only about one-third of the samples show low Zn status.**

- ↔ **Based on the indicators mentioned in Para (1) above, the following observations were made, in general:**

- ↔ **In Walajah Tank command area, the soil status in areas under the command of 4 channels fell under medium to high soil fertility. While, the villages under the command of the remaining 8 channels had low to medium soil fertility.**

↔ The soil status of the entire command area of Perumal Tank was categorized, in general, as high to medium fertile.

↔ In light of the above observations, it was found that the Perumal Tank command area had better soil fertility status compared to that of Walajah Tank command area.

❑ Recommendations

- As the major problem identified in the pilot study with regard to irrigation water quality is the adverse effect of huge quantity of suspended micro sized coal dust particles in Neyveli mine waters, it is recommended to store water in Walajah Tank before it is released for irrigation.

- Presently as the Walajah Tank is not functioning as an effective storage unit due to excessive silting and encroachment, it is just diverting the mine waters received by it through various off taking channels. Hence, it is strongly recommended to restore the tanks with the original storage capacity. This would help in creating adequate depth of water storage for effective settling of the micro sized particles present in mine waters.

- **Over the years, as a result of continuous usage of the highly turbid mine waters for irrigation in Walajah Tank command area, the bulk densities of field soils have increased more than the optimum levels there by hampering the permeability of soil, poor physical condition and decreased nutrient availability for crop growth.**

- **Add more of organics like farmyard manual, crop residuals, press mud, organic wastes, other farm wastes and green manures, for decreasing the bulk density to create favourable physical environment for crop growth.**

- **It is observed that there was a decline in fertility status of soil particularly in the Walajah Tank command areas. One of the main reasons for low fertility status could due to the continuous growing rice crops that is Kuruvai,** Samba, Navarai without any crop rotation. This is being practiced in these areas, as there is continuous receipt of water from Neyveli mines.

- To grow green manure crop in rotation and to incorporate the same in soil, which would greatly improve the fertility status of soil. It is also recommended to have crop rotation instead of mono cropping of paddy.

- It is also observed that there was a wide spread deficiency in Zn status in soil of both Walajah and Perumal Tank command area. Recommended to add Zn fertilizers to increase crop yields.

- To summarize, restoring the original storage capacity of Walajah Tank for effective settling of sediments in mine water, incorporation of various organic waste and farm waste, inclusion of green manure to improve both physical status and nutrient availability of soil in order to sustain the soil health and to realize better yield thereby improving the standard of living of the farming community.

- The results of socio-economic impact study revealed that to some extent the water has damaged the quality of soil especially in Walajah Tank command and affected the crop yields. The respondents suggested appropriate treatment of water be made before it was released from Walajah Tank for irrigation.

- Silting, weeds and encroachments that prevent water storage and water flow to be tackled.

- As suggested by the respondents it is recommended to strengthen the agricultural extension services in order to suggest appropriate farming practices and strategies to improve the soil quality and agricultural productivity of the command area.

THANK YOU VERY MUCH FOR YOUR KIND ATTENTION