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Effects of Lignite Mine Drainage on Irrigated Command Areas - A Case Study

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Abstract: Irrigated agriculture is dependent on an adequate water supply of usable quality. Intensive use of nearly all good quality supplies means that new irrigation projects and old projects seeking new or supplemental supplies must rely on lower quality and less desirable sources. To avoid problems when using these poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to the best use. The mine drainage water pumped out continuously from the open cast lignite mines of the Neyveli Lignite Corporation Limited, Neyveli, Tamilnadu State, India, is received by two system tanks (small reservoirs) used mainly for irrigation. This has encouraged the farmers in the command areas of both tank systems to go for more than one rice crop in a year. Even though, over the years, the farmers have been benefited by this supply of continuous water from mines in addition to rainfall and runoff from respective catchments of the tanks, in recent times, they opine that the coal dust laden mine water used for irrigation had affected the crop yields. Investigations were carried out with the objectives (1) to assess the status of quality of surface waters released from the two tanks for irrigation in the respective command areas and (2) to assess the likely effects of quality of water on soil and on growth and yield of crops grown in the command areas.

Key words:

INTRODUCTION

Irrigated agriculture is dependent on a sufficient water supply of utilizable quality. In the past water quality apprehensions had often been neglected because good quality water supplies had been plentiful and readily available. But the situation has changed in many areas. Many irrigation projects have to rely on lower quality and less desirable sources of water supply. In order to avoid problems when using such poor quality water supplies, there must be sound planning to ensure that the quality of water available is put to best use.

The effect of water quality upon soil and crops must be better understood in selecting suitable alternatives to cope with potential water quality related problems that might reduce production under prevailing conditions of use.

Conceptually, water quality refers to the characteristics of a water supply that will influence its suitability for a specific use, that is, how well the quality of water meets the needs of the user. Quality is defined by certain physical, chemical and biological characteristics. In irrigation water quality evaluation, importance is placed on the chemical and physical characteristics of the water and only rarely is any other factor considered important.

The quality of the available supply must be evaluated to see how it fits the intended use. Most of the experience in using water of different qualities have been gained from observations and detailed study of problems that develop following the use of such waters. The cause and effect relationship between a water constituent and the observed problem then results in an evaluation of quality or degree of acceptability. Due to sufficient reported experiences and measured responses, certain constituents emerge as indicators of quality- related problems. These characteristics are then organized into guidelines related to suitability for use. The guidelines presented in FAO Irrigation and Drainage Paper 29 (Revised 1)[1] give more practical procedures for evaluating and managing water quality-related problems of irrigated agriculture.

Two tanks (small sized reservoirs) namely, Walajah Tank and Perumal Tank, in Cuddalore District, receive mine drainage water pumped out continuously from the open cast lignite mines of the Neyveli Lignite Corporation Limited, Neyveli, Tamilnadu State. This water had been used by the beneficiaries in the irrigated commands of both Walajah Tank and Perumal Tank for more than three decades. Recently, they had raised apprehensions on the quality of mine drainage waters they were using for raising crops in the commands of both the tanks.

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They tend to feel that the coal dust laden mine water used for irrigation had affected the crop yields.

This prompted us to take up a study with the following objectives.

- Assessment the status of quality of surface waters released from the two tanks for irrigation in the respective command areas.
- Assessment of the likely Impacts of quality of water on soil and on growth and yield of crops grown in the command areas.

Water Quality Problems: Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. Salts are present in relatively small but significant amounts. These salts are usually carried with the water to wherever it is used. In case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop.

The suitability of water for irrigation is determined not only by the total amount but also by the kind of salt dissolved. Various soil and cropping problems develop as the total salt content increases, and special management practices may be required to maintain acceptable crop yields. Either water quality or suitability for consumption is judged on the potential severity of problems that can be expected to develop during long-term use.

The problems vary both upon kind and degree, and are modified by soil, climate and crop, as well as by the skill and knowledge of the water user. As a result, there is no set limit on water quality; rather, its suitability for use is determined by the conditions of use which affect the accumulation of the water constituents and which may restrict crop yield. The soil problems, most of which commonly encountered and used as a basis to evaluate water quality are those related to salinity, water infiltration rate, toxicity and a group of other miscellaneous problems.

The rising food demands of the world population have often led to the use of marginal salt-affected soils and/or low quality waters. Thus, salinity of arable land is a mounting problem in many irrigated areas of the world and is an important factor in dipping crop productivity [2, 3] (Srivastava and Jana, 1984; Szabolcs, 1979).

A salinity problem exists if salt accumulates in the crop root zone to a concentration that causes a loss in yield. In irrigated areas, these salts often originate from a saline, high water table or from salts in the applied water. Yield reductions occur when the salts accumulate in the root zone to such an extent that the crop is no longer able to extract sufficient water from the salty soil solution, resulting in a water stress for a significant period of time. If water uptake is appreciably reduced, the plant slows its growth rate. The plant symptoms are similar in appearance to those of drought, such as wilting, or a darker, bluish-green colour and sometimes thicker, waxier leaves. Symptoms vary with the growth stage, being more noticeable if the salts affect the plant during the early stages of growth. In some cases, mild salt effects may be entirely unnoticed because of a uniform reduction in growth across an entire field.

Salts that contribute to a salinity problem are water soluble and readily transported by water. A portion of the salts accumulated from prior irrigations can be leached below the rooting zone if more irrigation water infiltrates the soil than being used in the crop season. Leaching is the key to controlling a water quality-related salinity problem. Over a period of time, salt removal by leaching must be equal or exceed the salt additions from the applied water to prevent salt building up to a damaging concentration. The amount of leaching required is dependent upon the irrigation water quality and salinity tolerance of the crop grown.

An infiltration problem related to water quality occurs when the normal infiltration rate for the applied water or rainfall is appreciably reduced and water remains on the soil surface too long or infiltrates too slowly to supply the crop with sufficient water to maintain acceptable yields. Although the infiltration rate of water into soil varies widely and can greatly be influenced by the quality of the irrigation water, soil factors such as structure, degree of compaction, organic matter content and chemical make-up can also greatly influence the intake rate.

The two most common water quality factors that influence the normal infiltration rate are the salinity of water (total quantity of salts in the water) and its sodium content relative to the calcium and magnesium content. High salinity water will increase infiltration. Low salinity water or water with a high sodium to calcium ratio will decrease infiltration. Both factors may operate at the same time. Secondary problems may also rise if irrigations must be prolonged for an extended period of time to achieve adequate infiltration. These include crusting of seedbeds, excessive weeds, nutritional disorders and drowning of the crop, rotting of seeds and poor crop stands in low-lying wet spots. One serious side effect of an infiltration problem is the potential to cause disease and vector problems.

Toxicity problems arise if certain constituents (ions) in either soil or water are taken up by the plant and accumulate to enough high concentration to bring out crop damage or reduced yields. The degree of damage depends upon the uptake and crop sensitivity.

The permanent, perennial types of crops (tree crops) are the more sensitive. Damage often occurs at relatively low ion concentrations for sensitive crops. It is usually first evidenced by marginal leaf burn and interveinal chlorosis. If the accumulation is great enough, reduced yields result. The more tolerant annual crops are not sensitive at low concentrations but almost all crops will be damaged or killed if concentrations are sufficiently high.

Other several problems related to irrigation water quality occur with sufficient frequency for them to the specifically noted. These include high nitrogen concentrations in the water, overhead sprinkler irrigation with high bicarbonate water or water containing gypsum or water with high iron, unusual pH of water, water induced corrosion and incrustation. Vector problems often originate as a secondary trouble related to a low water infiltration rate, to the use of wastewater for irrigation, or to poor drainage. More commonly, sediments tend to fill canals and ditches and cause costly dredging and maintenance problems. Sediment also tends to reduce further the water infiltration rate of already slowly permeable soil.

The guidelines for evaluation of water quality for irrigation are given in Table 1. They emphasize the long-term influence of water quality on crop production, soil conditions and farm management.

The guidelines are practical and have been used successfully in general irrigated agriculture for evaluation of the common constituents in surface water, groundwater, drainage water, sewage effluent and wastewater.

Rice Crop Tolerance to Salinity: The tolerance for rice crop is shown in Table 2 below. Rice is categorized as a moderately sensitive crop with regard to salt tolerance. The soil salinity tolerances in Table 2 apply primarily to rice crop from late seeding stage to maturity stage. Tolerances during the germination and early seedling stage may be different and is clearly defined for a few crops.

The limits of the classification of irrigation water based on electrical conductivity are indicated in Table 3. Classification of irrigation water based on Sodium Absorption Ratio (SAR) is explained in Table 4.

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 River 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.

Table 1: Guidelines for Interpretation of Water Quality for Irrigation

		Degree of restriction on use		
Potential Irrigation Problem	Units	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
Bicarbonate (HCO_3) (Overhead Sprinkling only)	Mg/l	< 5	5 - 30	> 30
pH		Normal Range 6.5 – 8.4		

Table 2: Crop tolerance and Yield Potential of rice as influenced by Irrigation Water Salinity (EC_w) and Soil Salinity (EC_e)[4,5]

	Yield Potential (in percent)									
	100		90		75		50		0	
Field Crop	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

[4,5] Adapted from Maas and Hoffman (1977) and Maas (1984)

Table 3: Classification of Irrigation Water Based on Electrical Conductivity[6]

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

[6]Adapted from USSL (1954)

Table 4: Classification of Irrigation Water Based on Sodium Absorption Ratio[6]

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.

[6]Adapted from USSL (1954)

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. The total command area of 4577.21 hectares of Walajah Tank System distributed in 22 villages is served by 12 channels.

The Perumal tank has a combined catchment of 552.9 sq. km and an original capacity of 16.25 Mcum. During the years it has silted up in part and its current capacity is estimated at 13.5 Mcum. The tank supplies water to an indirect command of 2,636 hectares through 11 channels. 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.

Climate, Rainfall and Soils: The climate of the area is typically monsoon. The hottest months of the year are

May and June when average monthly maximum temperature exceeds 37°C. The coolest months of the year are January and February when the average monthly minimum temperatures are less than 20°C. The relative humidity is less during the hot months and more during the cold months. It ranges from 58% in May to 81% in December. The annual average relative humidity is about 68%. Wind speeds are mild ranging from 5 km/h in the month of March to 12 km/h in the month of June. The average number of hours of bright sunshine per day is about 8. These data pertain to the India Meteorological Observatory located at Annamalai University, Annamalainagar, which is the nearest weather station to the study area.

Rainfall in the study area is predominantly influenced by the North-East Monsoon during the months of October to December. It receives comparatively less rainfall during the South-West Monsoon period during the months of June to September. The average annual rainfall was 1284 mm. The maximum and minimum observed annual rainfall were respectively, 1838 mm and 755 mm. Nearly about 27% of the annual rainfall occurs during the South-West monsoon period and about 64% during the North-East monsoon period. The remaining 9% of the annual rainfall occurs during the dry season (January to May).

Soils in the Sethiathope Command consist predominantly of fine grade alluvial soils, clays and clay loams traversed by zones of coarser soils of sandy loams.

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.

Methodology: Surface water samples were collected at representative locations by using the standard technique. The sampling locations include feeder canal to the tanks, upstream side of the tanks, downstream side of the tanks, head, middle and tail reaches of all the irrigation channels originating from the tanks.

The water samples collected from the command areas of both tanks were analyzed using standard procedures laid down by APHA at Environmental Engineering Laboratory of Department of Civil Engineering, Annamalai University.

RESULTS AND DISCUSSION

Irrigation Water Quality - Surface Waters of Walajah Tank and Perumal Tank Systems: Electrical conductivity of water samples drawn from various approaches of different channels of Walajah Tank System showed a variation from 1.016 dS/m to 2.200 dS/m. In case of 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 passages of various channels taking off from Perumal Tank System ranged between 0.526 dS/m to 1.531 dS/m. The water samples drawn from six out of the eleven channels of Perumal tank system were within 0.750 dS/m. Comparatively, the EC values of waters of Perumal Tank System were 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 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 was 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. However, 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, 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.

Therefore, according to the guidelines to 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 for utilization of water for irrigation. Referring to the US Salinity diagram for irrigation water, in general, the irrigation water of Walajah Tank may be categorized as Class C3-S1 (that is, Low sodium hazard and Medium-high salinity hazard). The quality of water of Walajah Tank for irrigation is under moderate category.

In case of Perumal Tank System, the irrigation waters of two channels fall under the Class C2-S1 (that is, low sodium hazard and moderate salinity hazard). The quality of waters of these two channels for irrigation is under good category. The quality of irrigation waters of the other channels of Perumal Tank fall under the category C3-S1 (moderate quality).

Hence, due to the above standards as well as the consideration of the crops grown in the commands of both Walajah and Perumal Tank irrigation systems, there is no problem of salinity and of infiltration caused by SAR. Nevertheless, the farmers of Walajah Tank System, in particular, state that there has been reduction in the yields of rice crops grown in the command area in the past decade or so. Why?

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 was attributed mainly to the colloidal suspended particles, largely, the coal dust from the Neyveli Mine Drainage. This aspect was strengthened by the high content of suspended solids in many of the water samples drawn from different locations in the channels. This revealed that the Walajah Tank was not functioning as an effective storage unit and merely acted as a receiving unit before conveying the mine drainage from it directly to the off-taking irrigation channels. 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. Furthermore, 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. Totally, 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 ways 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 was 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 is necessary to evaluate the fundamental physical properties of field soil samples namely, bulk density, particle size distribution and permeability.

Physical Analysis of Soil Samples: Table 5 shows the optimum bulk density for maximum plant available water and field range bulk density densities for a range of textures.

Comparing the data from Archer and Smith [7] in Table 5, it is clear that for sandy soils with a low plant available water capacity that an increase in bulk density

Table 5: Optimum Bulk Density@ for maximum Plant Available Water and Field Range Bulk Densities for a Range of Textures[7]

		Field Density (under cultivation)	
Soil	Optimum density (g/cm^3)	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 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 the increase in bulk density raises 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, and this leads to limit growth and distribution as well as 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, the bulk densities of most of the field samples of soil drawn from cultivated lands of Walajah Tank Command were higher than those drawn from Perumal Tank Command. Sieve analysis was also performed on undisturbed soil samples collected from the command in the head approaches 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 is 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 in the study area were very less. This might have hampered the growth of the crops grown in the study area.

CONCLUSIONS

- The electrical conductivity of water samples drawn from various passages of different channels of Walajah Tank System show 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 passages of various channels taking off from Perumal Tank System ranges between a low of 0.526 dS/m and a high of 1.531 dS/m.
- Comparatively, the EC values of waters of Perumal Tank System are less than the waters of Walajah Tank System.
- As the storage capacity and catchment area of Perumal tank are much higher 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 rainwater 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 is much higher.
- 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.
- The irrigation water of Walajah Tank may be categorized as Class C3-S1 (that is, Low sodium hazard and Medium-high salinity hazard).
- The quality of water of Walajah Tank for irrigation is under moderate category. In case of Perumal Tank System, mostly, the irrigation waters of fall under the Class C2-S1 (that is, low sodium hazard and moderate salinity hazard).
- There is no problem of salinity and of infiltration caused by SAR in the commands of both Walajah and Perumal Tank irrigation systems.
- The turbidity of irrigation waters flowing in many of the channels of Walajah Tank System is high.
- 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, greatly the coal dust from the Neyveli Mine Drainage.
- 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. 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.

- The turbidity of waters released through the channels of Perumal Tank system for irrigation is very less. The higher available storage capacity of Perumal Tank is effective in trapping the suspended particles present in water.
- The bulk densities of almost all samples collected from the Walajah Tank command are 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 are relatively lesser.
- The physical characteristics of soil samples drawn from various irrigated fields of Walajah Tank indicate that there is a likely problem of infiltration.
- The current physical nature of the soils is not permeable to the extent needed by the crops grown in the command area. As the permeability is less, it would reduce the uptake of water by the root tips and cause a water stress situation to the crops. This would affect the yield of the crops.
- The higher bulk density and reduced permeability of soil samples may be attributed to the suspended micro-sized particles in the mine drainage. These particles in irrigation waters clog the pores in the soil and reduce the infiltration of water. This necessitates the removal of such suspended colloidal particles from mine waters before they are used for irrigation in the commands of Walajah Tank.

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