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The Soil Survey of Bhairavanitippa Project Area — An Irrigation Soil Survey

by

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Introduction: The soil survey of the Bhairavanitippa Project area was undertaken late in 1950 in order to find out the suitability of the soils and water for irrigation. The command area is situated in the Ceded districts of Bellary and Anantapur, far in the interior of the Deccan Peninsula without any high mountains nearby. So the area enjoys a very limited rainfall (about 20 inches per annum) and is subject to famine conditions very frequently. The Tungabadra project which is to be the salvation of the Ceded districts will not confer any benefit on this tract. The only source of irrigation in the region is the river Hagari. This is not a perennial stream and is in floods for only a few days in the year. Still, to improve the tract and to prevent famine conditions, it is proposed to harness the waters of Hagari for irrigation by throwing a dam across it just above the Bhairavanitippa village of Kalyandrug taluk of Anantapur district. The reservoir will have a storage capacity of 2,000 million c. ft. (effective capacity 1500 million c. ft.) and two irrigation channels are proposed to be taken from the reservoir one on either side of the river to irrigate a total area of about 8,000 acres.

2. **Traverse and soil survey:** In order to study the topography and the nature of the soils and to select sites for the profile pits, a traverse of the project area was undertaken. During the traverse the following characteristics were noted: (1) the surface features of the land such as flat, undulating, broken, etc.; (2) the soil-water conditions including drainage; (3) the texture of the soil such as sandy, loamy, clayey etc.; (4) the colour of the soils; (5) the depth, succession and nature of the horizons of the soil profile down to the parent rock and (6) the nature of the cropping and the natural vegetation in the tract.

During the traverse and soil survey on both sides of the river Hagari, 42 profile pits were dug to represent the typical soil types of the area and 112 samples of soil were collected for analysis in the laboratory. These soil samples were cut out from the vertical sides

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of the profile pits dug to the parent rock or the water table. Where the horizons were too deep or indistinguishable, soil samples were drawn for every six inches of the profile. The different horizons or depths of the profile were tested in the field for pH with pH paper, for alkalinity with phenolphthalein and for calcium carbonate with dilute hydrochloric acid. The colour, texture, structure, consistence, organic matter content, root penetration and salt, if any, in the horizons or depths were also noted in the field.

Samples of water from the river which is to be harnessed for irrigation were collected and brought Coimbatore for analysis. Water samples were also collected from some spring channels in the river Hagari and from irrigation tanks in the locality to get some information regarding the nature of the water used at present for raising crops.

The project area: The project area lies on both sides of the river Hagari, 6,000 acres on the left flank in the Rayadrug taluk of Bellary district and 2,000 acres on the right flank in the Kalyandrug taluk of Anantapur district. The slope of the land is generally from the alignment of the main irrigation channel (which is at the highest contour) on either side to the river Hagari. So the river forms the natural drainage channel for the area. The land is in some places uneven and broken and may have to be levelled up before irrigation can be undertaken. However, the larger portion of the tract is only gently undulating to the river. The soil consists mainly of shallow red soil, 6" to 24" in depth and sandy to loamy in texture with patches of deep red soil, black soil and mixed soil. The whole area is thinly populated.

The dry crops of the area are largely groundnut, cholam and cumbu with cotton, varagu, horse-gram etc. to a smaller extent. Under garden conditions ragi is cultivated extensively with occasional raising of tobacco, onions etc. Paddy is the main crop under wet cultivation. The natural vegetation in peromboke lands is Cassia auriculata. The leaves of this plant are used by farmers as green manure for the wetlands. Very little attention seems to be paid to dry land cultivation in the tract and no manures are used. In garden lands, sheep-penning is generally done while paddy lands receive scanty dressings of green leaves.

Geology of the Tract: The rocks of the project area consist of a granite and gneissic complex. The red soils are probably formed

from Potash felspars while the black soils are derived from Soda lime felspars. Kankar is found in all the soil types and gypsum is not present in any profile in appreciable amounts.

Hydrology: There are no wells in the dry lands of the ayacut area. A few, however, have been dug in the mixed soil and black soil areas where garden cultivation is carried on. The water table is low being below 18 ft. in most wells in September.

Drainage: Most of the dry uplands consisting of shallow red soils are porous in the lower depths and have good drainage. The mixed soils and black soils are lower down in the contour but as they have loamy sub soils, water logging is not likely on irrigation.

Erosion: The rainfall in the project area is, on the average, about 20 inches per annum. But the rain is often received as torrential falls and considerable run-off and sheet erosion of soil occur. Gullies found in many places in the tract are evidence of the damage caused.

Soils: The soils of the ayacut area may be divided into 4 groups. These are (1) shallow red soil 6 inches to 24 inches in depth and sandy to gravelly in character. This type forms the major soil of the tract. A large amount of stones of all sizes and shapes are found on the top of the soil. (2) Red soil 3 to 4 feet in depth. This type is sandy to sandy loam in character and occurs in patches on both flanks of the project area. (3) Mixed soils: These are 3 to 4 feet in depth and are found on both sides of the river where irrigation has been carried out with water from the spring channels. They are grey to black in the top 6 to 8 inches and brown to red in the lower depths. The top soil is generally a clay-loam with a loam as the sub soil. (4) Small areas of black soil of depth 3 to 4 feet occur in both the flanks of the ayacut area.

The mixed soils and black soils which have been irrigated with spring channel water from the Hagari have developed alkaline patches in some places.

3. **Laboratory Examination of soils and water:** In a survey to find out the irrigability or otherwise of an area, the most important analytical data required are (1) the suitability of the water for irrigation; (2) the salt content of the soil in the different horizons of the profile; (3) the texture of the soil and (4) the drainage facilities of the soil. So all the water samples and all the 112

samples of soil collected during the survey were analysed to obtain the above information. However, to obtain a complete picture of the soil types, one profile pit in each type has also been studied for fertility status, base exchange capacity and exchangeable Calcium. The following estimations were carried out:

(1) Moisture in the air dry soil.

(2) Mechanical composition such as the percentages of Clay, Silt, Fine sand and Coarse sand and the percentage of stones and gravel to fine soil of 2 mm. diameter and below.

(3) Alkalinity studies such as total soluble salts, Carbonates, Bicarbonates, Chlorides and Sulphates of Calcium, Magnesium and of monovalent metals like Sodium.

(4) pH and Conductivity.

(5) Fertility status including loss on ignition, insoluble and soluble mineral matter, total and available phosphoric acid and potash, total nitrogen and calcium.

(6) Base exchange studies consisting of base exchange capacity and exchangeable calcium.

(7) The water samples were analysed for total dissolved salts, carbonates, bicarbonates, chlorides and sulphates of calcium, magnesium and sodium and for pH.

Discussion of the analytical data: *Mechanical Composition*: The shallow red soil which forms the major portion of the ayacut area contains a high percentage of stones and gravel in all depths while the other soil types contain stones and gravel sufficient to prevent water-logging.

The fine soil passing through a 2 mm. sieve has been fractionated into clay, silt, fine-sand and coarse sand according to the International method of analysis. The shallow red soils range from sandy to clay loams, the coarser fractions varying from 50 to 92 per cent. The clay content increases slightly with depth. The mixed soil is mainly a clay loam with a preponderance of coarser fractions. The coarser fractions increase with depth. The deep are mainly sandy red soils loams with over 75 per cent of sand. The mechanical composition of the black soils would put them in the

clay group with over 30 per cent of particles of diameter, 0.002 mm. and less. The soils suspected to be alkaline range from loams to clay soils. They appear to have been formed from mixed and black soils by the accumulation of sodium salts.

The texture of the soils, especially of the shallow red soil which forms the major soil type of the project area is such that drainage will be efficient. Water-logging is not likely on irrigation except in the black soil. This forms only a negligible proportion of the ayacut area and need not be taken into consideration.

Soluble Salts: The total soluble salts are low in the shallow red soils and deep red soils, the amounts being 0·02% to 0·03% and 0·01% to 0·08% respectively. The mixed soils and soils suspected to be alkaline contain fairly high percentages of salts, the value ranging from 0·1% to 0·59%. There is no salt accumulation in any of the profiles studied.

One general feature noted with regard to the soluble salts is that they consist mainly of Sodium (mono-valent) compounds with little or no soluble Calcium salts. There is not much of Sodium Carbonate in the red soil types while Sodium Carbonate and Bicarbonate are present in the mixed and black soils and in the alkaline soils in appreciable amounts. It is a well known fact that a high amount of Sodium salts in the soil is not good for crop production, especially if the Sodium salts exist as Carbonate and Bicarbonate. Judged by the above dictum, the shallow red soils and the deep red soils are good for crop production while the other types are not good.

The pH values of the soils reflect on their soluble salt content and the nature of the salts. Except for a few of the shallow red soils and the deep red soils which have pH values between 7 and 8, all the other soils of the project area are highly alkaline. The soils reported to be alkaline have pH values between 9 and 10. There appears to be a fair amount of Calcium Carbonate in many of the soils. But the high pH induced by Sodium Carbonate and Bicarbonate renders it impossible for the Calcium Carbonate to get into soluble condition.

Base Exchange Studies: The black soil has high base exchange capacities varying from 34 to 57 milliequivalents per 100 gm. of soil. The other soil types are of medium to low base exchange

capacity, the shallow red soil which is the predominent soil type of the area having a base exchange capacity below 10 milli-equivalents.

In the case of a soil having a low base exchange capacity, the entry of Sodium into the exchange complex even in small amounts would constitute an appreciable amount of the total. That is to say, the degree of alkalinisation of the soil would be noticeable with even a small amount of exchangeable Sodium and when the degree of alkalinisation exceeds 30 per cent, the soil would become bad for crop prodution. The shallow red soil which covers about 60% of the ayacut area has a low exchange capacity and irrigation with Hagari water containing sodium salts would bring about its alkalinisation in a few years. To prevent this, organic matter must be incorporated into the soil in adequate amounts. As is well known, organic colloids have 5 to 6 times the base exchange capacity of clay and so will increase the exchange capacity. Moreover, during the decomposition of organic matter, acids are formed and this will lower the pH of the soil and bring into solution Calcium from the Calcium Carbonate of the soil. Organic matter, has also other desirable properties such as binding the loose soil and opening up heavy soils. So the incorporation of heavy doses of organic materials into the soil is advocated when irrigation is given to the soils of the project area.

In the soils of the project area, Calcium appears to be the dominant cation at present. So the soils have now a high lime status. But the picture would be different in a few years' time if Hagari water containing sodium salts is used continuously for irrigation. Gradually the Calcium of the exchange complex would be replaced by the Sodium of the irrigation water and the potentialities of the soil for crop production would become reduced. In a few years' time it would become alkalinised to such an extent that it would be unfit for cultivation. The soil will develop into a typical alkali soil. So, irrigation with Hagari water must be undertaken with caution.

Fertility Status: The soils of the project area are generally of low fertility status. Nitrogen is deficient in all the soil types. There appears to be sufficient amount of total phosphoric acid but available phosphoric acid is in deficit. Potash, both total and available, is present in adequate amounts. Total Calcium is present

in most of the soil types in good amounts, but available Calcium is low. Organic matter also is inadequate in the soils.

pH and Conductivity: The pH of the soil types has already been discussed. There appears to be only slight correlation between the Specific Conductivity values and the total soluble salts present in the soil.

Water: Hagari water taken from different locations in the river and water from the spring channels in the Hagari have been analysed.

The water from the Hagari river and from the spring channels contain considerable amounts of salts and these salts consist mainly of Sodium carbonate, bicarbonate, chloride and sulphate. Calcium and magnesium salts are present only in small amounts. As is well known Sodium Carbonate and bicarbonate are also toxic to plants. Water containing appreciable amounts of sodium salts should not be used for irrigation. The quality of irrigation water may be determined by the salt index formula of A. N. Puri (Irrigation Institute, Punjab). According to him,

Salt Index = (Total Na − 24·5) − " (Total Ca − Ca in Ca CO_3) x 4·85". All quantities refer to parts per 100,000. Salt Index is negative for good waters and positive for those unfit for irrigation. If the water from the river Hagari and the spring channels are tested with this formula, it is found that all of them are unfit for irrigation purposes. With regard to bicarbonates in the irrigation water Wilcox etal (1954) state that Eaton's conception of "residual sodium carbonate" which he defined in 1950 as $(CO_3^{--} + H\,CO_3^{-}) - (Ca^{++} + Mg^{++})$ appears to be useful for classifying irrigation waters having $H\,CO_3^{-}$ in excess of divalent cations. It is concluded that waters containing more than 2·5 me/l of "residual $Na_2\,CO_3$" are not suitable for irrigation while those containing between 1·25 and 2·5 me/l are marginal and that those containing less than 1·25 me/l are probably safe. If Hagari water is measured with this yard-stick, it is found to be unsuitable for irrigation.

Reifenberg (1947) in Palestine has found that fertilizing the soil with potash and phosphatic manures prevents the intake of sodium chloride from saline irrigation waters.

It is also a well established fact that once Sodium enters the exchange complex of the soil, it can be removed only with difficulty

with the use of costly amendments. So the use of Hagari water for irrigation purposes is open to considerable doubt.

4. **Final Conclusions and Recommendations:** From what has been seen of the soil in the field and from the analytical data obtained in the laboratory, it has been concluded that the main soil types of the ayacut area, namely, the shallow and the deep red soils, are suitable for irrigation. But the water which is proposed to be used for irrigation is unsuitable as it contains considerable amounts of Sodium salts.

Under normal circumstances, Hagari water containing appreciable amounts of Sodium salts cannot be recommended for irrigation. But under the peculiar condition obtaining in the project area where the Hagari is the only source of water and where scanty and uncertain rains frequently entail famine conditions, it is to be considered whether the project is to be proceeded with. Fortunately, the major portion of the area consists of shallow red soils with a very low salt content, excellent drainage and a natural gradient towards the river which is very suitable for providing adequate drainage. Another redeeming feature is that the water that will be impounded in the reservoir will be the flood waters of the Hagari and these may not contain so much of salts as the river water in summer which was examined by us. So the project may be proceeded with provided certain precautions and adjustments are undertaken. These are (1) the water should be used judiciouly to avoid possible dangers of water-logging; (2) the drainage system should be adequate and efficient; (3) organic matter must be incorporated into the soil in adequate amounts to build up the base exchange complex of the soil and to bring down the pH. This may be done by growing leguminous green manure crops with the application of phosphate manures and ploughing them in. The green manure seed should be inoculated with the specific bacterium before sowing, (4) salt tolerant varieties of food crops should be grown in the tract such as S. R. 26 B in the case of paddy etc. (5) The soils should be given adequate doses of potash and phosphatic manures to increase fertility and to prevent the intake of sodium salts from the irrigation water.

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