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CONJUNCTIVE USE OF GROUNDWATER AND CANAL WATER IN BASALTIC UPLAND AREA OF MAHARASHTRA

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ABSTRACT

The paper presents results of hydrogeological studies carried out in two representative river basins of upland Maharashtra. These results are well comparable to other river basins in basaltic upland terrain. The river basins of upland Maharashtra have been divided into three groups which provide knowledge about the riverine sediments from groundwater point of view. The aquifers in the Deccan Trap and riverine sediments yield water from 12 to 400 lit/day and 135 to 1000 Klit/day during summer respectively. Isolated saline tracts are common along the riverine sediments of each group. Geochronology of the area suggest that the Quaternary sediments generally yield saline water. Based on geohydrological studies, suggestions have been made for planning and implementation of conjuctive use programme in river valley projects in basaltic upland area of Maharashtra.

GEOMORPHOLOGY

Maharashtra State is divided by the Western Ghat (Sahyadri mountains) forming two major landforms, namely,(i) coastal area on western side, and (ii) upland area on eastern side. The upland area presents land forms gently slopping towards east with broad shallow valleys, while on coastal sides it is dissected by deep almost V-shaped valleys.

Drainage of the upland area of the Maharashtra is influenced by three main river basins namely, Krishna in southern, Bhima in central and Godavari in northern portion. The rivers generally show easternly gradients. However, extreme northern portion of upland Maharashtra is drained by westernly flowing rivers, namely, Tapi and Narmada. All the river basins are drained by large number of tributaries. The river tributaries except Narmada and Tapi rivers which are mainly considered in this paper are grouped into three types based on their morphotectonic features. They are (i) rivers which originate in the continental divide but meet the main river in comparatively short distance, (ii) rivers which originate in the continental divide but meet the main river at comparatively long distances and (iii) rivers which originate away from the continental divide and meet the main rivers. Figure 1 and Table 1 presents the three different groups.

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The findings recorded in this paper are based on author's own observations, and in no way related to Govt.policy.

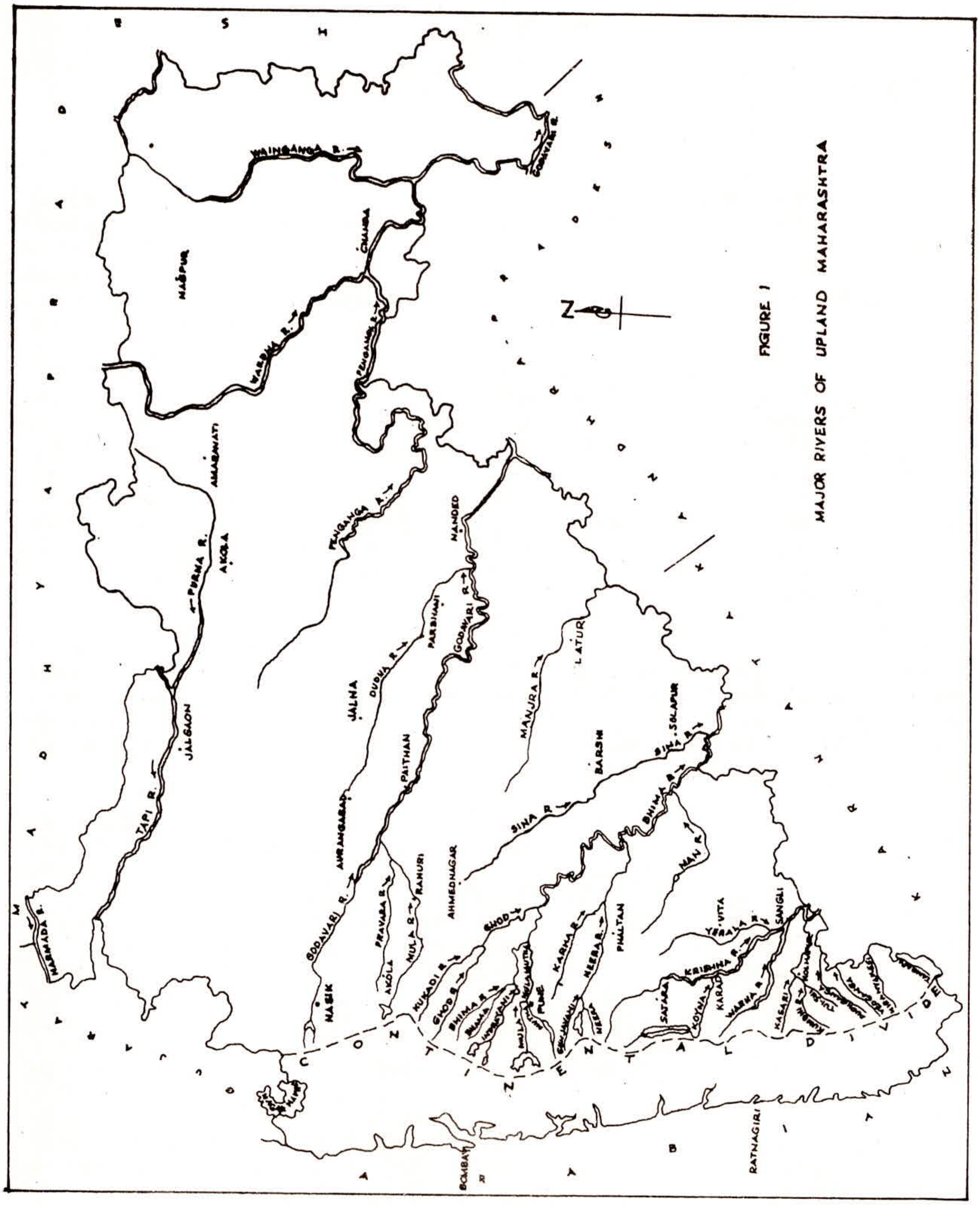

FIGURE 1
MAJOR RIVERS OF UPLAND MAHARASHTRA

Table 1

Sr.No.	Group	Important rivers	Riverine, sediments extent		Characteristics
			Lateral	Thickness	
1	2	3	4	5	6
1	A	Warna, Koyna	1 to 5 km	30 m	Lateritic clay and silt.
		Nira, Mula, Pravara			Light grey Clayey with carbonate nodules.
2	B	Tamraparni, Hiranyakeshi, Vedganga, Dudhganga, Group of Panchganga	1 to 1.5 Km.	10 to 20 m	Lateritic clay and silt devoid of carbonates
		Gunjawani Indrayani, Bhama, Ghod, Kukadi etc.			Greyish, brown soil with carbo-nate nodules
3	C	Yerala, Karha, Man, Sina, Manjra	0.50 to 15 Km	10 to 25 m	Rich in carbonate nodules

GEOLOGY

Geology of about 85 percent area of upland Maharashtra is marked by Cretaceous-Eocene flows of Deccan basalts. The remaining portion consists of Dharawars, Kaladgis and Gondwana formations. All formations show residual weathering developing laterites crust at the top. In valley sections riverine sediments of Pleistocene and Recent/Sub-Recent are of common occurance.

Varieties of basalts

The basalts show varied lithological characteristics with almost uniform mineralogical composition. The predominent varieties of basalts are compact porphyritic basalt, amygdalo-idal-vesicular basalts, volcanic breccia (clinkers), red bole etc. It is noticed that certain varieties of basalts appear to be predominent in certain areas.

Kolhapur

Predominance of thick extensive compact flows of basalt with vesicular and amygdular structures at the base and top.The flows are commonly interspaced by volcanic breccia and red tachylitic basalt.The area is mostly devoid of dykes.

Pune

Moderately thick,comparatively less extensive flows of predominently amygdaloidal-vesicular basalts with volcanic breccia and red bole tops. The area is witnessed by dykes.

Solapur

Comparatively thin flows forming irregular thickness of compact porphyritic and amygdular varieties with volcanic breccia and red bole tops but without dykes.

Ahmednagar and Aurangabad :

Predominance of thin flows of amygdaloidal basalt with limited lateral extent and with comparatively less common volcanic breccia or red bole horizons.

Physical characteristics

A huge pile of countless lava flows erupted intermittently are spread all over. The volcanic breccia/clinkers show heterogeneous structural and field characteristics with uneven lateral extent.

The compact porphyritic flows show cooling joints. Joints vary in shapes and spacing. The amygdular variety of flows are comparatively less jointed. The secondary tectonic joints/fractures are commonly noticed in all varieties of the basalts. Primary porosity in the basaltic formations is almost negligible, but secondary porosity is developed due to weathering and tectonic joints which are predominently responsible for the storage of groundwater. Basalts on weathering give rise to spheroidal weathering at many places. Highly weathered basalt locally known as "murum". Amygdaloidal basalts on weathering develop sheet joints, one above other. Secondary porosity developed in volcanic breccia due to weathering is comparatively more than in any other variety of basalts.

Two types of dykes are common in Deccan Traps. One is moderately spaced horizontal and vertical to sub-vertical joints, and other is with highly jointed close spaced. Most of the dykes (fresh), predominently of first group are impervious; and few dykes of second group are pervious. Secondary porosity developed in dykes due to weathering is more along margins than in central portion.

RIVERINE DEPOSITS

The flows of the Deccan basalts are commonly covered with alluvium on either banks of the rivers. Lateral extent and thickness of these sediments depend on magnitude of the stream,local geomorphology and palaeotectonics.

The river deposits of Tamraparni, Hiranyakeshi, Vedganga, Dudhganga, Tulshi, Dhamni, Kumbhi, Kasari, Warna and Koyna which represent group B comprise lateritic red silty and clayey soils with basal conglomeratic beds consisting loose to semiconsolidated, gravels, pebbles of different varieties of basalts and laterites. One significant observation in these formations is that the upper alluvial soil do not carry pockets of sand or calcarious concretions.

Riverine deposits of rest of the rivers of group-C contain calcareous concretions and irregular lenticular sand pockets above the basal conglomerate, which have generally wide lateral extent and commonly found along major river courses. Lateral extent of basal conglomeratic bed is largely dependent upon shifting of the drainage courses.

Primary porosity in the basal conglomerate is more, but it is reduced at places due to ferruginous or calcareous cementations. Secondary porosity is developed in overlying clayey and silty soils due to development of calcareous concretions and nodules, which give rise to open spaces between the two.

Lateritic red clayey and silty riverine sediments of rivers of southern upland area show that they are of Mid-Holocene period (Tandale-c). The sediments of Krishna and Godavari, Pravara and Mula rivers show that they are of Pleistocene and Recent to Sub-recent. (Rajguru, Kale , Tripathi). A geological succession in these basins have been generalised as follows.

Sub-Recent/Recent	Colluvium, alluvial soil, poor in calcareous nodules with sand pockets
Pleistocene	Alluvial soil rich in calcareous nodules with intercalation of sand pockets with vertebrate fossils
Cretaceous to Eocene	Fresh and weathered Deccan Trap basalt with dykes.

AQUIFERS

The average annual rainfall of different parts of upland Maharashtra are as follows; towards east of the continental divide it varies from 700 to 3000mm; while little away from here, i.e.Sangli, Solapur, Nasik, Dhule 600 to 700 mm. Towards Osmanabad,Aurangabad,Amravati 700 to 900 mm while towards Nanded,Yeotmal 900 to 1100 mm; and towards Bhandara, Chandrapur-1100 to 1700 mm.

Contribution towards ground water storage in upland area of Maharashtra is predominently from rainfall, percolation through unlined canals, large reservoirs, surplus irrigation water, and artificially recharging structures such as percolation tanks. Important aquifers in basaltic terrain are (i) weathered basalt,(ii) fractured and jointed amygdaloidal and compact porphyritic basalt, (iii) highly fractured dykes, (iv) volcanic vents/conduits,(v) fracture zones,(vi) intertrappeans of grity and cavernous limestones. Red/green /black boles,(also called as red beds, tachylitic basalt) fresh amygdaloidal basalts, compact dense basalt and intertrapeans consisting of shales are the common aquicludes in the basaltic terrain.

Results of chemical properties of the groundwater samples collected in the Pravara and Mula sub-basins revealed that waters are dominated by alkalies and strong acids, and on the basis of electrical conductivity the waters can be classified as saline. The geochronology of Pravara and Mula sub-basins suggests that most of the saline water samples are from the aquifers of Quaternary deposits(Tandale -b). Though the alluvial deposits of command area of Jawalgaon medium irrigation project in Sina river basin do not provide data on their age, this may be true in the case of these deposits also. It is noted that the aquifers of riverine sediments which contain lateritic clayey and silty soils of rivers of southern upland do not yield saline water.

Conjuctive Use of Groundwater And Canal Water

Out of 307696 sq.km. area of the Maharashtra, 208 lakh hectares land is under irrigation by all sources (1984-85 assessment). About 65% of the total population of the Maharashtra is dependent on the agriculture. In the recent years, it has been experienced that there are repeated drought conditions, which consequently decreased the total agricultural produces. It has now been realissed by all that there should be economical use of water.

It has been noted that most of the major and medium irrigation projects are located accross major river courses along which flood plain deposits are seen. Porous and pervious horizons of these flood plains form the promising aquifers in the valley portions. In addition, promising aquifers of Deccan Traps alsos occur in the command area. It is noted that such areas having considerable groundwater potential come under command of irrigation projects.

Case Studies

Pravara and Mula Sub-basins

Hydrogeological studies have been carried out in Mula and Pravara sub-basins (rivers of Group A) in Godavari main basin (Figure 2) and along the banks of Nagzari river which is sub-tributary of Sina river of group C. Some portion of Mula and Pravara sub-basins come under the command area

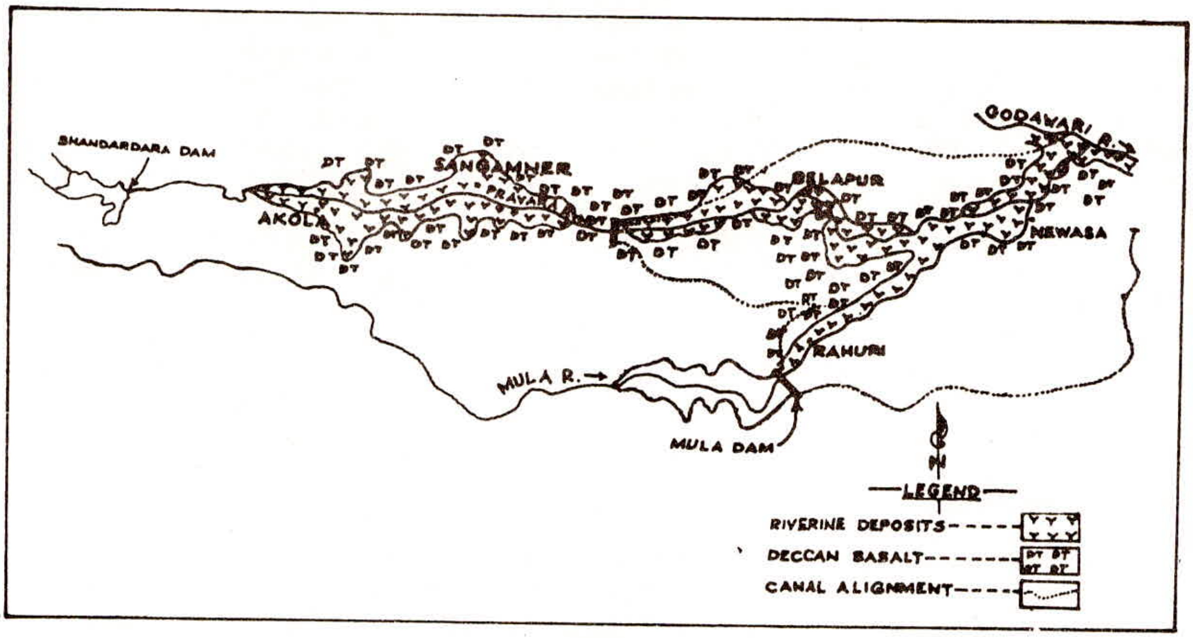

FIGURE 2

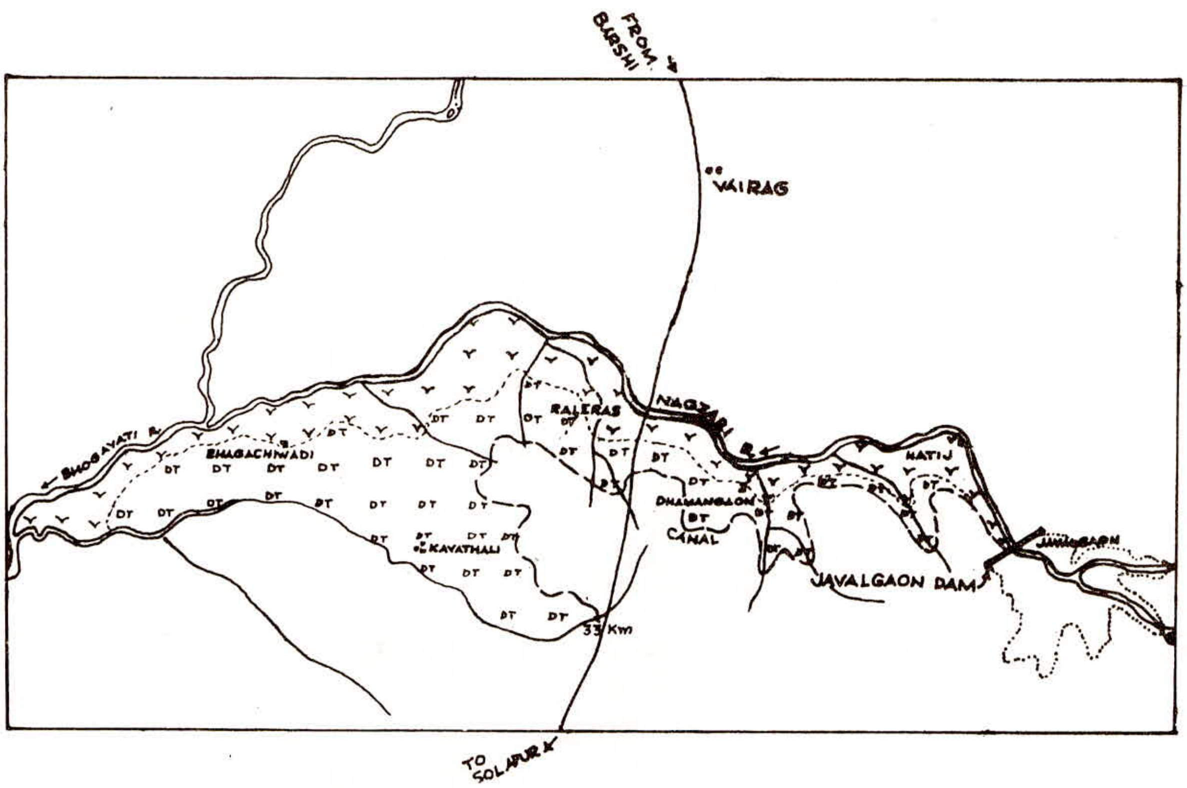

FIGURE 3

of Mula dam having 737 MCM storage capacity and command area about 7.959 lakh hectares and the Bhandardara dam having about 312.6MCM storage capacity with command area 228 lakh hectares Alluvial tracts of the Nagzari valley are covered under command area of Jawalgaon Irrigation Project (Figure 3) having storage capacity 29.70 MCM and command area 6200 hectares.

In the Mula and Pravara sub-basins five different types of aquifers are found to be productive; namely (a) basal conglomerate and sand pockets,(b) alluvial soil with calcareous nodules and sand, (c) colluvium, (d) weathered traps below the alluvial deposits and (e) weathered amygdular/ vesicular horizons with fracture zones without alluvial cover (Tandale-a).

Basal conglomerate and sand pocket

Semiconsolidated to consolidated alluvial basal conglomerates consist of pebbles of traps and secondary minerals. The conglomerates are generally porous, permeable and measure about 0.3 m in thickness. They occur between 10 to 33 m below the ground level and yield 196 to 1000 Klit/day during summer.

Alluvial soil with calcareous nodules and sand

Alluvial soil cover carry discontinuous pockets and lenses of sand and gravels mixed with silt and calcareous concretions. They disconformably overlie the basal conglomerates and unconformably over Deccan basalt depending on the disposition of basal conglomerate. Alluvial deposits range in thickness from 15 to 30 m. It yields about 96 to 360 Klit/day during summer.

Colluvium (Slope wash)

Colluvium which consists of angular pieces of basalts set in silty and clayey alluvial soil, have very limited lateral extent along the foots of the hills. The wells tapping these aquifers yield about 68 to 90 Klit/day during summer.

Weathered traps beneath the riverine sediments

In the areas where alluvial deposits do not exceed 12 m in thickness, wells are tapping this aquifer, and they yield about 120 Klit/day during summer.

Weathered amygdular and vesicular horizons with fracture zones

Along the banks of the rivers and in the command area of Mula and Pravara Projects, there are some pockets, where weathered amygdular and vesicular horizons exist without cover of riverine sediments. Wells tapping these aquifers

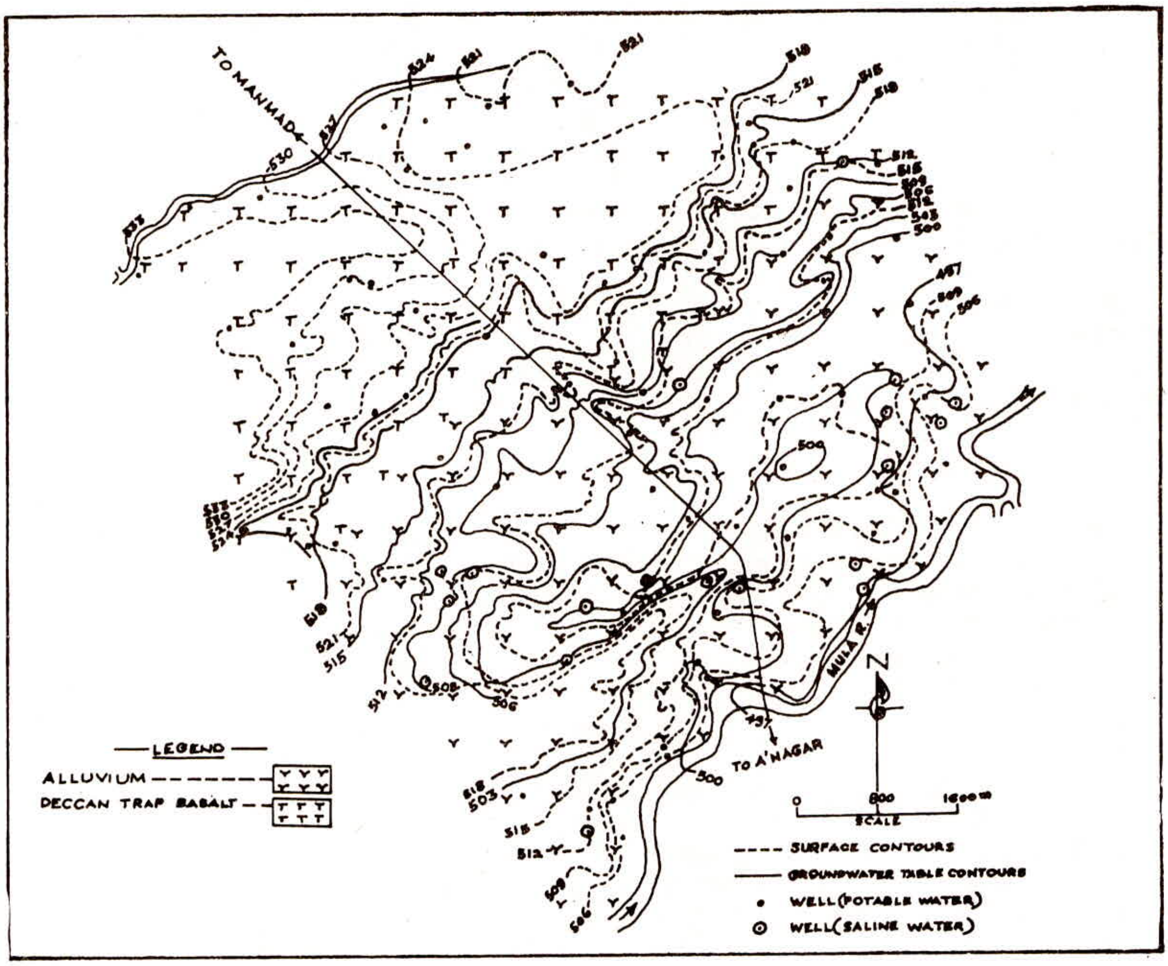
TO MANMAD
TO A'NAGAR
MULA R.
N
LEGEND
ALLUVIUM
DECCAN TRAP BASALT
0
800
1600 m
SCALE
SURFACE CONTOURS
GROUNDWATER TABLE CONTOURS
WELL (POTABLE WATER)
WELL (SALINE WATER)

FIGURE 4

yield 45 to 400 Klit/day during summer.

Geohydrological investigations carried out around Rahuri (about 500 m above msl) about 46 sq km in the command area of Mula left bank canal, three types of aquifers are found. They are namely, riverine sediments with basal conglomerate, amygdaloidal basalt (weathered and fractured) and compact porphyritic basalt (weathered, jointed/fractured) and they yield 135 to 1000 Klit/day, 12 to 550 Klit/day and 45 to 640 Klit/day during summer respectively (Tandale-b) Figure 4 shows a geological map around Rahuri with groundwater contours. The data suggest that the hydraulic gradiant in riverine sediments is of the order of 2.4 m/km, while in the traps it is 3.5 m/km. The ground water levels measured in summer and winter seasons indicated, that they fluctuate from 0.40 to 5 m in the basltic aquifers, and from 0.10 to 2.80 m in the wells tapping in the riverine sediments. The investigations revealed, though riverine sediment and Deccan basalts occur in juxtaposition they vary widely in respect of groundwater behaviour.

The groundwater potential in Mula and Pravara sub-basins covered with riverine sediments is estimated to be 18 MCM, while withdrawal is about 15 MCM leaving possibility of some enhancement of potential for future use.

Nagzari Sub-basin

The geohydrological observations made in the command area of a recently constructed medium dam, near Javalgaon in Barshi tahasil of Solapur district, across the Nagzari river, which is subtributary of Sina, also compares well with those observations in the Pravara and Mula sub-basins. The command area of Javalgaon dam is about 6200 hectares designed to irrigate by 30 km long left bank canal.

On left bank of the Nagzari river geology is marked by flows of Deccan basalt, while on right bank they are covered by riverine sediments. The thickness of alluvial deposits range from fraction of a metre to about 15 m. Geological mapping suggests that the river course has been shifted towards north from its earlier position, during the period of its deposition.

The observations before completion of the dam revealed that cultivators are in general irrigation minded and taking cash crops like sugarcane, grapes, tobacco, by lifting groundwater from wells predominently located in riverine deposits. Some of the cultivators have been traditionally lifting water by digging pits of about 2 to 5 m deep in the river bed and they are taking perennial crops. Towards the confluence of Nagzari and Bhogavati, there appear to be a burried river channel along its left bank.

Planning And Implementation of Conjuctive Use Programme

Judicious planning and implementation of conjuctive use of groundwater and canal water plays a major role in socio-economic development of the tract. As large number of natural and socio-economic problems are involved satisfactory implemention gets difficult. The geohydrological study indicated that Purna, Tapi and Godavari basins have extensive alluvial tracts both areally and in thickness and the conjuctive use of ground and surface water has enhanced the socio-economic status of the area to a considerable extent. But present work has revealed that such promising areas occupying other river basins yet await the full conjuctive use and need due consideration.

For planning of conjuctive use programme in command areas of irrigation schmes, they can be grouped into two , viz. first is under construction and proposed; and other is for completed schemes.

Irrigation schemes under construction and proposed

Based on hydrogeological studies carried out in the Pravara and Mula sub-basins of Godavari main basin, and in Sina sub-basin of Bhima main basin, planning would be in three stages. The first stage involves an assessment of groundwater potential in the command area. The second stage should include recording systimatically the changes in groundwater conditions based on which a proper implementation of conjuctive use programme would be planned. In the report of stage -III to be prepared during implementation of conjuctive use programme, detailed observations should be recorded and any modifications in the report if required should be suggested.

A detailed work programme for the above stages is detailed below :

Stage-I

Land to be proposed for conjuctive use at local village sector, may be as small as a portion of a survey number. It is suggested to prepare report on planning programme on following points.

i) Preparation of geological maps of command area on village map scale, showing all varieties of basalts.

ii) Detailed well inventory of all existing wells.

iii) Preparation of aquifer map on village scale based on aquifer studies.

iv) Preparation of groundwater contour map.

v) Selection of representive wells to be monitered as observation wells.

vi) Determination of chemical quality of ground water from irrigation point of view, with correlation to geology.

vii) Investigations by geophysical experiments to find out deeper aquifers.

viii) Asssessment of groundwater potential and suggest aquiferwise number of wells feasible.

Stage-II

Observations during transitional period between stage-I and implementation programme (i.e.stage II) to be carried out are detailed below.

i) Monitering of representative wells selected earlier at one month interval at least for two consecutive years.

ii) Scrutinising groundwaters level data as observed during stage I.

iii) Aquiferwise yield study.

iv) To suggest areas suitable for conjuctive use programme based on aquifer performance experiments and groundwater potential available for further developments.

v) Correlationof groundwater data with drought,if experienced.

vi) Economics of new wells may be worked out on the basis of following aspects.

a) Reassesment of available ground water potential.
b) Type of basalts in which well is to be dug.
c) Likely yield of well.
d) Power required to lift water.
e) Cropping pattern etc.

vii) To finalise cropping pattern. In the areas of good yielding aquifers perennial crops may be suggested.

viii) In the light of observation recorded in stage-II report, to suggest modification, if required.

Stage-III :

i) For judicious and fruitful conjuctive use programme, obsersvations regarding groundwater such as changes in groundwater levels, its withdrawal, cropping pattern are required to be continued and correlated with cycles of watering by canal, rechanging of groundwater storage due to surplus water used for irrigation, and suggest modifications, if required.

ii) For reassessment of groundwater potential following formula is suggested.

Available groundwater + recharging due to canal = withdrawal of groundwater + groundwater retained in aquifer + effluent seepage + evaporation of groundwater.

iii) Recharging due to canal water : Experiments in the Sina basin have shown that seepage rate vary from 3.59 to 6.08 cumecs/MCM for unlined canals through basalts, while it is 1.69 to 3.4 cumecs/MSM through black cotton soil. It was estimated that total seepage loss varies between 8 to 35% of the discharge released at the head of the canal (Sehgal).

iv) Experiments in Deccan Traps have shown that there exists no cone of depression(CGWB) therefore criterion regarding distance between the two wells required is required to be considered.

v) After construction of additional wells, cropping pattern and conjuctive use is required to be balanced so that there should not be over withdrawal and well should not affect adversely.

vi) Cultivators in the command area may not intend to lift water from wells. Therefore some guide lines may be suggested to the policy making authority. For this purpose, cultivator may be taken in confidence and his difficulties be solved on merits.

Conjuctive Programme In Case Of Completed Irrigation Projects

i) In case of completed major and medium Irrigation Projects, either banks of rivers in the command area are generally occupied by the riverine sediments, whichare found to be promising productive aquifers. (e.g.Mula and Pravara) but the same area is being provided by canal irrigation (Figure 2). Some projects of upland Maharashtra are more than 20 years old. Under such circumstances,it may be difficult to convince cultivators for well irrigation, because construction of well, energisation, provision of pipe lines,etc. are involved. For such activities availability of funds,man power,etc.are required. It appears that if encouraagement policy is framed in the interest of cultivators and they are convinced about availability of groundwater,they may participate in the conjuctive use programme.

ii)Since data regarding groundwater conditions before construction of a dam is not available to estimate and assess groundwater potential, investigations such as preparation of geological maps,aquifer maps,groundwater level contour maps, their correlation with canal seepages, surplus irrigation water recharging groundwater, drought condition if occured., monitoring of wells etc.is required to be carried out in accordance with the guide lines described in stage-I and II.

iii)On complete review about available groundwater potential, characterisation of aquifers, suitable areas in command area for conjuctive use may be finalised with suitable cropping pattern.

iv)Large command area of major irrigation projects covered with flow of Deccan basalt may have been traversed by fracture zones/dykes forming promising aquifers. For such delineation areal photographs studies followed by ground check should be done.

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