To harness the water of Betwa river, Matatila dam has been constructed for irrigation as a joint venture of Madhya Pradesh and Uttar Pradesh states. Its command area forms a small part of the Yamuna drainage basin and is bounded by Sind and Pahuj rivers. The Sind river originates near the village Nainwas in Vidisha district and joins the Yamuna river after a journey of about 395 Kms. near the village Kaudhcoli in Uttar Pradesh. The important tributaries of the Sind river are Kunwari, Vaisali and Pahuj rivers. The total cultivated area of Matatila Command in Madhya Pradesh is 10,9621 hectares, whereas the gross command area is 12,1152 hectares. The main canal known as the Bhandar main canal, irrigates parts of the Bhandar tehsil of Gwalior district, Seondha tehsil of Datia district and the Lahar tehsil of the Bhind district. The Bhandar canal has three major distributaries known as Daboh, Akheda distributary and Lahar branch canal. The cultivated area coming under the Bhandar canal in Datia district is about 26,923 hectares, while in Gwalior district, it is 17,800 hectares. The gross command area, available for irrigation
is about 27,076 hectares in Datia district and 20,882 hectares in Gwalior district.

The study area forms a part of the Matatila Command which falls in the tail reaches of the Bhandar canal system in Datia & Bhind districts of Madhya Pradesh. Due to the adoption of high yielding varieties of crops, vagaries of monsoons and other interstate problems, the tail reaches of the canal systems are unable to meet the irrigation requirements of the crops even during the winter season. Apart from this problem, the formation of ravines, headward erosion, water-logging and bad quality of groundwater are also present in the Matatila Command area. Therefore, to find out the solutions for these problems, the area which falls in the lower reaches of the Matatila Command has been taken up for the study.

The area of the tail reaches of Matatila Command falls on the Survey of India toposheet Nos. 54 K/9, 54 K/10, 54 K/11 and 54 J/12, 54 J/13, 54 J/15 & 54 J/16 which falls between (Longitude E 78°, 35' to Longitude E 79° & Latitude N 26° to Latitude N 26° 25') and covers an area of about 2001 square Kms. This area lies in Datia and Bhind districts. The area is approachable by train as well as by buses.
It is criss-crossed by a number of metalled and tar roads permitting easy access to any part of the command. The important towns of the study area are Lahar, Ron and Seondha.

(4) Hydrometeorological study carried out with the view to determine the water balance of the basin for developing and managing its water resources. The climate of the Matatila Command can be designated as semiarid, characterised by extreme of temperature, variable and uncertain rainfall. The winter season is normally cold, while the summer season is hot and dry. The rainy season is quite pleasant with sporadic greenery. Generally, December and January months are the coldest months, May and June are the hottest months, whereas July and August are the wettest months of the year. The maximum temperature of the area varies from 27.87°C (February) to 45.25°C (May) and minimum temperature ranges from 3°C (February) to 24.12°C (May). The pan evaporation losses go on increasing from the month of January up to month of May. Then it decreases till August and again increases during September and October. During the winter season it becomes very low. It varies from 12.06 cm. to 26.93 cm. for Bhind district whereas in Datia district,
it ranges from 12.06 cms. to 27.30 cms. Thus the evaporation losses for the Datia district are greater than Bhind district though the summer months of Bhind district are hotter than those of Datia district. The percentage humidity is the maximum in the month of August. From September onwards, the percentage humidity gradually decreases till November and then from December to January, it gradually increases. The month of May has the lowest humidity percentage.

The weighted average normal rainfall which is determined for a period of 86 years (1901-1986) of the Matatila Command is 640.0 millimeters. The analysis of the rainfall data has revealed that for about 65 days in a year, rainfall can keep the soil moisture zone sufficiently saturated with water and the farmlands do not require any irrigation. If about 100 days are utilised for preparation of land in between two crops, during the remaining 200 days, the crops require irrigation from other sources of water as per their irrigation schedules.

The remote sensing technology has been found applicable to different aspects like surface water mapping, geological mapping, geomorphological
mapping, watershed survey, determining groundwater potential zones, landuse, environmental monitoring, forest mapping and delineation of regional geological structure of the present study area. In some cases, the technique acts as a new tool while in others as a supplement to the existing techniques. The use of the remote sensing data as a first step helps to narrow down the target area for further detailed exploration. This has greatly reduced the cost and time in the study.

(7) The Sind river basin presents a picture of elusive simplicity with only two divisions separated by an erosional unconformity. The lower basement complex comprises of the Bundelkhand granite and gneiss which constitute the oldest, while the alluvium constitutes the youngest one.

(8) The sediments constituting the alluvium have been drawn from the weathering and transportation of the different lithological formations present in the command area. Therefore, the sediments are of mixed type. In the Pahuj-Sind drainage basin, alluvium and clay beds predominate over sands, gravels and pebbles, etc.

(9) The correlation study of the subsurface geology reveals that the first aquifer consists of fine to
coarse-grained sands. It is also present throughout the area. In general the thickness of the clay unit remains the same in all the bore holes of the section line except in those bore holes situated in the vicinity of the villages Ron & Machharia which are closer to the Sind river. The upper surface of the first aquifer generally lies at an approximate depth of 25 meters below the ground surface. The upper surface of the second aquifer occurs at an approximate depth of 75 meters below the ground surface.

(10) The thickness of the alluvium in the area is not much. The maximum thickness of alluvium is about 82 meters which is found in the bore hole located near the village Ron. The thickness of the alluvium increases from the south to the north and also from west to east of the study area.

(11) In order to demarcate groundwater potential zones in the area, hydrogeomorphological studies have been carried out. These studies include physiography relief, slope analysis, drainage pattern and their analysis, vegetation and the various landforms of the hydrological interest.

Physiographically the area has two broad units namely, the lower extension of Bundelkhand plateau
and the Gangetic plain. It is mostly a flat and undulating terrain covered by the alluvium with a few isolated outcrops of Bundelkhand granites. The maximum ground elevation of the command is 200 meters whereas the minimum ground elevation is 120 meters above M.S.L. The area has mostly gentle slope ($10^\circ$-$15^\circ$) towards the north-east.

(12) The Matatila Command area falls in the Sind drainage basin, which is a subdrainage basin of the major Yamuna drainage basin. Sind drainage basin has an area of 30,152 sq.kms. and it is elongated in shape. The pattern of the drainage in the above said basin are of four types, viz. dendritic or tree like drainage pattern, parallel drainage pattern, dichotomic and fault trellis pattern.

(13) Drainage basin analysis has been carried out in order to determine the various important parameters of hydrogeological interest. These are drainage density, drainage frequency, drainage texture, drainage intensity, bifurcation ratio, length of overland flow and length ratio. The calculated values of drainage density for the present basins, i.e. Sind main basin and Pahuj basin are 0.546 and 0.350 Km/sq/cm. respectively whereas the derived values of drainage frequency in Pahuj basin is 4 Sq Km. and in case of Sind main basin, it is 6 Sq Km. The
drainage texture of each basin has been determined and found that is extremely coarse in both the basins. Drainage intensities for Sind main basin & Pahuj basin are 12.96 and 8.57 respectively. Length of the overland flow for Pahuj river basin is 1.42 Kms. whereas for the Sind main basin, it is 0.916 Kms. In Pahuj basin bifurcation ratio varies from 1:2.6 to 1:6.2 and in Sind main basin it varies 1:3 to 1:3.7. This means that in next higher order, the total number of streams of a given order gets reduced 2 to 6 times in Pahuj river basin and almost 3 to 4 times in the main Sind basin.

The length ratio ranges from 1:1.5 to 1:1.7 in Pahuj river basin and from 1:2.6 to 1:1.5 in the Sind main basin. This means that the mean length of stream just gets doubled or almost tripled as it enters next higher order in Sind main basin whereas almost doubled in the case of Pahuj basin. Summing up the result of these variations, it can be concluded that from a particular order to the next higher order, the mean length of stream gets doubled or tripled but the number is remarkably decreased 2 to 6 times in Pahuj basin and 3 to 4 times in case of Sind main basin. The systematic study of all these parameters plays very important role for the localisation and assessment of groundwater resources.
The area is nearly devoid of vegetation. There is no thick forest in the area. The important trees are of Sagon (Tectone grindis), Tinsa (Qu Geneva daberoids), Saj (Termotia tomentus), Mahua (Bassia latifolio), Ber (Ficus bengalensis), Babul (Acacia arabica), etc.

Geomorphic set up of the area has considerably influenced the groundwater occurrence. Therefore, hydrogeomorphological map of the study area has been prepared with the help of Landsat imagery. The study area is classified into (a) hilly region consisting of massive units of Bundelkhand granite, (b) Flat terrain covered with alluvium, (c) ravines occurring on the banks of the Sind and Pahuj rivers. In the central alluvial plains, occasionally, the narrow ridges of quartz reefs are present and act as groundwater barriers. Towards the extreme north, near the Seondha town, the quartzite rocks of the Gwalior group form a fairly broad plateau with steep scarp to the south. The groundwater potentiality of the area comes under excellent to good class.

The most important hydrolitho units of the area are the sand horizons. These horizons are varying in grain size, having more permeability with 20-30% porosity. The sand horizon have been classified into
three categories viz. fine sand, medium sand and coarse sand.

In the fine sand horizon, one should not expect more water. This is met mostly in dug wells and the yield is not much. The thickness of the aquifer varies from 4 to 6 meters and this is the upper aquifer zone of the area. It is the shallow aquifer which is not in position to supply good quantity of water.

Medium sand horizon is met in most of the area concealed under a thick layer of clay. Due to presence of clay layer above the medium sand layer, the groundwater occurs mostly under semi-confined to confined conditions. This aquifer zone discharges water more than 9000 gph as observed in the field. Thus, the yield of this zone is much better than in fine sand horizon.

The coarse horizon is most important because it has good porosity and permeability. The yield of this horizon is more than 10,000 gph. It also possesses confined condition.

(17) Electrical resistivity surveys employing the schlumberger electrical soundings have been carried out at the sites which have been selected on the basis of remote sensing study. The sounding curves
mainly represent three and four layers. In most of the cases, the top layer resistivity ranges from 5 ohm-m to 55 ohm-m which indicates presence of coarser material like sand, gravel, and boulders. These materials exhibit 20-50 ohm-m resistivity when they are devoid of clay and saturated with water. Thickness of this layer ranges from 0.8 meter to 9 meters. The second layer resistivity ranges from 10 ohm-m to 168 ohm-m with thickness varying from 4 to 39 meters. 10 to 15 ohm-m resistivity of this layer is attributed to clay beds whereas the resistivity ranges from 15 ohm-m to 38 ohm-m may correspond to the water-bearing sandy horizon. The resistivity values between 30 ohm-m to 168 ohm-m may be attributed to the semi-weathered, fractional and jointed granites which may also be water-bearing. The third layer is a hard and compact basement granite indicated by very high resistivity with curve attaining 45° slope in the last segment in several cases. In the four layer cases, the third layer resistivity ranges from 5 to 60 ohm meter. The variations in resistivity are due to the variation in degree of weathering and intensity of fracturing and jointing & water holding capacity of granules. The fourth layer resistivity in these cases is attributed to hard and compact basement.
The aquifer characteristics namely ('T' & 'S') have been determined by using the Papadopulos & Cooper's method in large diameter wells including dug-cum-bore well. The coefficient of transmissibility value for the first aquifer varies from 40 to 350 m$^2$/day. The coefficient of storage values lie in a range of 0.0001 to 0.00008. It is noticed that the 'S' value is not reliable. By applying the Theis non-equilibrium method, the coefficients of transmissibility and storage have been calculated. Coefficient of transmissibility (T) varies from 200.68 m$^2$/day to 343.24 m$^2$/day, whereas storage coefficient varies from $1.24 \times 10^{-4}$ to $9.42 \times 10^{-5}$. These values indicate that the well yields are adequate enough for irrigation purpose.

The water level fluctuation in groundwater varies from 0.49 to 6.30 meters in the village Ron and from 0.44 to 3.15 meters in the village Lahar. In the northern part of the area, towards the west of the village Ron, the fluctuation contours are closely spaced which indicate that fluctuation is more towards the west of the Ron village. It means that this area acts as a recharging area whereas in the southern part, the contours are widely spaced indicating less fluctuation and it is a non-recharging area. Groundwater level maps reveal
that the movement of groundwater is towards the main river courses. In the area towards the east of Lahar, the water table contours are closely spaced indicating presence of less permeable strata whereas presence of widely spaced contours shows more permeable strata. The area around the village Daboh acts as a discharge area because from all around the flow directions of the groundwater are towards the Daboh village.

The pressure surface contours which are shown in the pressure surface map, are widely spaced to the north of the Lahar town, whereas they are closely spaced to the south of the Lahar town. Therefore, it becomes clear that area to the north of the Lahar village is more permeable. The area around the villages Ajner and Kherigpur acts as a discharge area. The movement of the groundwater is shown in figure by arrow.

The annual groundwater increment for the basin is 0.044 million hectare meters, which is calculated by groundwater level fluctuation method. The annual groundwater utilisation by the different sources is 0.018 million hectare meter. Hence, the balance of the available groundwater for exploitation is 0.026 million hectare meter every year. But after the advent of the irrigation from the Bhandar canal
system, the annual groundwater increment increases due to non-exploitation of groundwater. Therefore, one has to expect that more groundwater for exploitation is available than what is stated above.

(22) The quantitative assessment of the availability of the groundwater in the first aquifer present in the Pahuj-Sind drainage basin shows that the water-holding capacity of the first aquifer is 0.50 million hectare meters and its yielding capacity is 0.06 million hectare meters. The annual utilisation of the groundwater from the first aquifer is 0.015 million hectare meters. Therefore, the net available groundwater for the exploitation, present in the first aquifer is more than 0.044 million hectare meters.

(23) The qualities of groundwater and surface water in general are fit for irrigation but in a few localities, the quality of groundwater is unfit for irrigation. In the problematic area, it is suggested that the groundwater should be mixed with the surface water to improve the quality for irrigation.

(24) The alluvium of the Sind drainage basin appears to be the southern marginal fringe of the Indo-Gangetic alluvium, which has been deposited in for deep
depression in front of the Himalaya, that has come into existence due to the uplift of the sediments deposited in the Tethys sea.

Soils of the Matatila Command area may be grouped into high ground and low ground soils. These soils vary from sandy loam to clays. Below these soils occurs a substratum consisting of yellow clay with kankars. A semi-detailed survey conducted by the Soil Science and Agricultural Chemistry Section of the Agricultural Research Institute situated at Gwalior, shows that 75% of the gross Matatila Command area is irrigable (MPLIC, 1981). Saline and Alkaline soils comprise about 10% of the gross Matatila Command area.

The water-logging conditions of the Matatila Command are in the initial stage of development. The total water-logged area is 21,044 hectare. The water-logging conditions of the Matatila Command are of two types. The first type is due to: (a) seepage through the canals, (b) faulty functions of aqueducts and (c) destruction of the natural drainage conditions.

The second type is due to: (a) the presence of infiltration and recharging ground conditions in the area, (b) occurrence of water-bearing zones at
shallow depths and (c) excessive irrigation practices. The remedial measures for first type of water-logging are lining of canal floors and sides, deepening and widening of aqueducts, reopening of all the effective natural drainage course, construction of drainage channels parallel to the main canals. Wherever, seepage occurs, construction of drains to dispose off the surface runoff of low grounds into the natural drainage courses is necessary. For second type of water-logging conditions, the remedial measures require (a) determination of the extent of individual recharge and infiltration areas, (b) supply of irrigation water should be curtailed where the groundwater levels have reached upto the depth of one meter below the ground surface and (c) crop should be grown on the basis of groundwater level depth, (d) land shaping practices should be implemented carefully, (e) provision should be made for runoff from the fields and (f) exploitation of groundwater should be done in the area.

Depending on the hydrogeological conditions, the area under study is divided into three zones. The first zone covers an area of 94 square kilometers and it is suitable for dug wells. The second zone covers an area of 670 square kilometers which is suitable for the dug-cum-bore wells. The third zone
is meant for large production tube wells and covers an area of nearly about 478 sq.kms. The thickness of the alluvium is more in this zone so that deep tube wells can be drilled. The depth of the deep tube wells is generally more than 50 meters and the diameter of the tube well is about 0.25 to 0.30 meter.

In order to increase the amount of water in canals 290 tube wells with the average yield of 100 to 200 m$^3$/h may be drilled on either side of the Bhander canal and its tributaries, so that more area of farmlands can be brought under irrigation.

The soil erosion in the study area is very severe. The headward erosion of the ravines in the command area is common. There are three stages of the ravine formation. In the first stage the sheet washing of the loose soils capping the clay-kankary layer takes place resulting in minor depressions. In the second stage, the clay-kankary materials get pushed out laterally into the depressions due to groundwater pressures developing within them. This results in the caving of clay-kankary layer and then the roofs collapse into the caved parts. Thus, the headward erosion of the ravines progresses. In the third stage, the ground bursts caused by pressure due to removal of the overburden loads on the confined aquifer lead to the widening and deepening of ravines.
Soil erosion may be prevented by adopting suitable measures of soil conservation. Afforestation is one of the effective methods of soil conservation along hill slopes and other cultivated lands. It is suggested that where trees could not be grown, grass could be relied on as a very efficient substitute in the prevention of soil erosion. On gently sloping lands, contour ploughing, strip cropping and bunding helps in soil conservation. Gully erosion can be prevented by constructing check dams to prevent the spread of gullies.

Health hazard study has been undertaken to establish a correlation between quality of water and the diseases prevalent within the area under study. Out of 2609 surveyed people, only 600 are unhealthy constituting only 22.99% which clearly indicates that the groundwater is not much polluted, as evidenced from the 77.11% of the healthy people using the groundwater.

The diseases prevailing among the unhealthy people, have been classified into three broad categories. They are

(i) Cathartic physiological diseases.
(ii) Hypertension.
(iii) Miscellaneous (Congestive cardiac failure, renal diseases, cirrhosis of the liver, toxemia of pregnancy and meniere's disease, etc.)

(33) Percentage wise study of the people suffering from the above said diseases irrespective of male and female indicates that miscellaneous diseases are the least followed by cathartic diseases while the people suffering from hypertension predominate within the area under study. In author's opinion higher concentration of sulphate and sodium is one of the reasons for the aforesaid diseases respectively. Author recommends the sodium restricted diet for the long term management of hypertension and miscellaneous diseases.

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