CHAPTER VII

RESUME

> "We inherited earth from our forefathers Let us not leave it contaminated to our children and grandchildren."
>
> Hindu (1991)

The river Bhadar flowing towards south-west in Saurashtra, receives effluents from the dyeing and printing industries located on the bank of the river, at and around Jetpur. Lack of conscience on the degradation of environment on account of dye waste disposal, has made Bhadar a menace in the socio-cultural lives of the Kathiawaris. Looking into the aforesaid conditions of Bhadar valley, the research was carried out to delineate the deterioration and damage caused at large to the environment.

The rocks of Deccan Traps form the basement, over which the younger coastal Tertiary and Quaternary sediments have deposited. Within the limits of the Bhadar basin, the trappean rocks are exposed dominantly in the form of an uneven topography and at times minor hills. They are highly fractured and weathered. Their thickness is more than 400 mts. The traps generally comprise theoliitic basalt. The most common rock type is fine grained, compact, dark greyish basalts but vareities are not uncommon. The Osham hill consists of felsites whereas Alech hill comprises rhyolites and felsites with occasional dolerite rocks. The dykes cut across the basalts in three major directions namely ENE-WSW, NW-SE and E-W. The lineament rosettes (frequency and magnitude) confirm that all major rivers are draining along one or other major structural lineament. The rocks of Miliolite Formation rest unconformably over the traps. They are seen occurring along the Bhadar river from mouth upto Upleta. They occur as a sheet in the valley whereas as dunes in and around Jam Jodhpur. The coastal rocks are either sheet or coastal dunes. These rocks essentially comprise biogenic beach sands and/or are shallow marine deposits or reworked by the aeolian processes. Radiometric age determination has revealed the age of Miliolites to be ranging from 200 to 50 K.Y. The recent deposits are represented by a variety of unconsolidated sediments of beach, dune, estuarine, fresh-water and sub-aerial origin.

Geomorphologically, the basin can be divided into trappean highlands, pediments and coastal plains. The Bhadar originates from the highlands near Jasdan, flows in the south western direction for nearly 260 km distance, before meeting the Arabian Sea at Navibandar. Numerous tributaries are joining the main stream in the upper reaches itself and flows through the basalts of uniform resistance, showing a "dendritic pattern". Detail examination of the trunk stream as well as various tributaries and lower order channels reveal a complex intersection of fracture pattern and direction, relatied to various major lineaments.

Morphometric analyses of the micro-water sheds were carried out to decipher and understand the various factors responsible for the development of river patterns. The analyses reveal a) the effect of rejuvenation of the main trunk, b) structural control on low order streams, c) highly dissected drainage basin and d) low precipitation, high relief and high resistant rocks.

The Bhadar basin has uniform lithology with highly fractured and weathered rocks and falls in semi-arid climatic zone. The basin shows varied slopes from steep to sub-horizontal. The slope classes of Young's conincide with different landforms encountered within the basin. Steep slopes rest within the denudational hills, moderate slopes represent the pediment landforms, very gentle to level slopes occupy the burried pediment and flood plains.

The denudational hills represent an intrusive nature, stand-out prominently above pediment plain and are barren or scantily vegetated. These highlands show steep slopes greater than 18°, therefore, no significant soil horizons exist, which result into a fast run-off and very negligible percolation. Bhadar basin represented by pediment landform, supports scattered vegetation. The slopes are moderate (5°-10°), the run-off is quick with little chance of infiltration. The burried pediment has slope angles (5°-2°) with soil cover and is the largest unit. It represents grazing lands and agricultural lands depending upon the precipitation. It depicts less run-off and moderate to good percolation. Flood plains, are restricted along the tributary streams and the Bhadar river, which are well developed west of Jetpur. Often they are quite thick, highly fertile and support agricultural lands. The plains being more or less horizontal, having good infiltration and less run-off, act as good aquifers. The paleo-channels, having good potential for recharge to ground water have been identified near Jetpur and Upleta. Lobes, representing the paleo-mouth deposits of the Bhadar river when the sea-level was higher than the present were also demarcated. At present, they are partly covered below the recent marshes. Recent and paleo-dunes have developed along the coastline, comprising biogenic carbonate materials. The paleo-dunal areas have good vegetaion and human settlement. Marshes run more or less parallel to the coast and can be divided into high and low marshes, depending upon their indundation by the tidal water. This whole belt suffers from saline water ingression.

The geo-environment reflects the entire spectrum of human interactions with physical environment. It includes (i) physical conditions such as air, water, gases, landforms, etc. which affect the growth and development of a region and (ii) social and cultural aspects such a ethics, economics, aesthetic, etc. which affect the behaviour of the society.

Extensive mining of limestones and basalts have led to 1) the reduction of vegetational cover 2) noise pollution on account of blasting and movement of the heavy vehicles and crushing plants 3) air pollution on account of dust rise in the mining areas and in the vicinity of the crushing plants and 4) enhancement in the removal of various elements from the parent rocks.

The soil plays an important role in controlling the fauna, flora and ground water conditions. On the basis of "Soil taxonomy", soils within the basin have been classified into `Orthents' and `Orthids.'

Air pollutants are carbon monoxide, carbon dioxide, oxides of nitrogen and sulphur, hydrocarbon and their combinations. These gases are mainly on account of vehicular traffic on highway. However, air pollution is restricted to local areas, such as Gondal town, where oil producing industries are situated.

The basin experiences hot and dry summer from March to May and cold winter season from December to February. The monsoon period is from June to September and October-November form the post- monsoon season. The amount of rainfall varies from 250 mm to 600 mm.

The interplay of dynamic processes viz. sea-level changes and neo-tectonism during Quaternary have played a major role in shaping the landscape.

Biological conditions existing within the study area have been considered for evaluation of geo-environments.

Eight types of land use patterns were identified viz. (i) agricultural land (ii) grazing land (iii) barren/waste land (iv) forest (v) mining areas (vi) wet land (vii) residential/industrial area and (viii) water bodies. Recreation sites, within the study area, are in Virpur, Jasdan, Gondal, Upleta and Dhoraji. There is no breakdown in the ecological system, mainly considering the food chain and the habitat. However, the human activities in Jetpur have hampered the existence of live stock in the Bhadar valley on account of influx of the pollutants. After understanding the geo-environmental conditions of the Bhadar basin, the waste disposal of Jetpur dyeing and printing industry has been considered to be the major factor causing disturbance in the geo-environmental setup of the basin.

The interaction between topography, structure and sub-surface geology influences the hydrogeological characters, wherein the topography controls the run-off and recharge, while structure and sub-surface geology control the occurrence and potentiality of an aquifer. The ground water in the Bhadar basin occurs mainly in the unconfined aquifers which can be broadly classified as (a) consolidated formation (Basalts), (b) semi-consolidated formation (Miliolites) and (c) un-consolidated formation (Recent deposits). The movement of ground water in the basaltic rock is decisive and its dependence is on the secondary porosity such as joints, cracks, fractures and weathered zones. The development of these factors are not uniform and therefore the availability of ground water at depths varies from place to place. The Miliolite Formation being a calcareous sands, loosely consolidated, having good porosity and permeability, has been classified into semi-consolidated formation. Alluvial sediments are grouped into un-consolidated formation and they act as a good ground water aquifers.

Structures (joints and fractures) play an important role in hard rock terrains. Since these weak zones are of primary in nature, they augment the infiltration of the water to the sub-surface strata. Another important feature is the presence of dykes, which represent weak zones and have been identified as water barrier which inturn augments the recharge of the aquifers.

The geomorphic factors that control the hydrogeology of an area are (1) landforms, (2) slope, (3) the nature of bed rock and (4) effect of bed rock topography. The water level fluctuation in the aquifers, is controlled by the amount of recharge and discharge. The aquifers in the basin being unconfined in nature and assuming that they behave uniformly throughout the basin, the specific yield is analogous to that of co-efficient of storage. Based on the last ten years data, the reduced water level maps for pre and post monsoon seasons have been prepared. They depict that the water levels in both the seasons behave in same pattern. Comparison of water levels in the past (1984) and present (1993), shows a decline from 2 metres to 10 metres. The movement of water is in the direction along decreasing water heads and the general movement is from east to west. The variation in ground water flow directions are controlled by the criss-crossed fractures pattern which varies both in lateral and vertical extent.

The aquifers in the basaltic traps are unconfined in nature and can be classified into three minor aquifer systems such as (a) shallow aquifer in weathered profile, (b) multi-tier aquifer in different flows and (c) linear aquifer of fractured zones. The shallow aquifer in weathered profiles of basalts have thickness ranging from 2 metres to 14 metres and the water level in them ranges from 7.50 to 30.00 metres. The specific capacity of the shallow aquifer varies from 0.039 lpm/m to 0.271 lpm/min. The yielding capacity of these aquifers of the basin ranges from 0.01 lpm/min to 0.02 lpm/min.

Flows occur at depth below the weathered zone with intermittent massive or compact basalts. Therefore, this aquifer has been termed as multi-tier aquifer. They are connected by fractures and joints in the vertical direction. The water level varies from 10.50 metres to 114.00 metres. The total aquifer thickness is between 2.0 metres and 52.00 metres. The yield factor of the wells tapping multi-tier aquifers ranges from 0.003 lpm/min to 0.05 lpm/min.

Fractures are linear structures having secondary porosity, and act as good aquifers. Their morphology is elongated in linear fashion, therefore, are called linear aquifers. The depth of the fractured zone varies in thickness from place to place. The water level ranges from 15.00 metres to 64.00 metres. These aquifers show yield factor from 0.02 lpm/min to 0.003 lpm/min.

The Miliolite limestones are semi-consolidated aquifers, having primary and secondary porosities, and act as good repositories. Low topographic expressions, nearness to the sea have caused the water table to occur at low depth. Valley deposits are porous and permeable, having phreatic aquifer conditions.

Being semi-arid, the surface water occurrences depend on the amount of precipitation. Numerous man made structures on Bhadar and its tributaries have resulted into major areas of surface water occurences. The sub-surface water potentials are in Kamlapur, Bhadui, Gogavadar, Shapar, Gondal, Shivrajgadh, Jetpur, Vegdi, Gundasari, Sodavadar, Patanvav, Srinathgadh, Kotda Sangani regions.

The geo-environmental investigation of the Bhadar basin exemplarily depicts the deteriorated water quality . Therefore, the thrust has been given on the Jetpur due industry and its impact.

To achieve this various controlling factors and parameters were considered. The basin has been divided into three blocks - highlands, valley and coastal region. Water samples, both from surface and sub-surface from the same location for repetative seasons for pre and post monsoon seasons of 1993 to 1995 were collected. The sampling stations are grouped as (1) control point (2) point source (3) valley samples (4) sub-surface water and (5) coastal zone. The analyses of various parameters (physical, chemical and biological) were carried out strictly following standard procedures as suggested by American Public Health Association.

The results are of multivariant type in which location of observations are repeated and scattered within the blocks. Therefore, it is considered with clustering, classification and the examination of the inter-relationship among the data set, in which sampling locations are not taken into account. For this "Friedman test" has been used to bring out a single population mean values.

Local control samples will have more practical applications than the established standards. Hence, the control and non-control quality of individual parameters have been compared by applying t-test. Also, the quality of water between pre-monsoon and post-monsoon with respect to individual parameters were assessed.

Trace elements viz. Fe, Mn, Zn, Ni, Cr, Sr, Al, B, Cd, Cu, Pb, Co and F, have been analysed to understand the quality. The trace elements data reflect higher values when compared with the WHO and ICMR standards.

Statistical analyses reveal that the mean concentration of the variables is higher in the non-control than in the control for the surface and sub-surface water of the pre and post monsoon seasons. This amply points to the dye industrial effluent in Bhadar valley proper and saline water ingression in the coastal areas. The significance level of the pre and post monsoon water reveals that during the post monsoon the water quality improves which may be on account of dilution factor.

The quality of the water, both surface and sub-surface in the light of the analytical results, were estimated following Piper's diagram and water quality index (WQI). According to the Piper trilinear diagram, majority of the surface water in the Bhadar valley belong to Ca, Mg - Cl, SO_4 type in the pre-monsoon; while in post-monsoon season the surface water are equally distributed in all water class. However, the sub-surface water irrespective of seasons, are in the class excepting the Na, K - CO_3, HCO_3 type (sample from west of Warasara in the post-monsoon). Further, the diagram reflects that the Na + K (alkali) dominance in both pre and post monsoon samples of surface and sub-surface water in the coastal areas. The Cl field is dominant over the rest. In the diamond plots, major samples fall in the Na, K - SO_4, Cl field.

WQI of both pre and post monsoon seasons' surface water reflect that those of the tributaries to Bhadar are satisfactory, whereas the rest are either poor or unacceptable for drinking. The sub-surface water WQI reflects that samples from Pedhla, Panchpipla, east of Bhuki, Survo nadi (bank) and west of Warasara are satisfactory , but the rest are poor or unacceptable. In the coastal tract, the results of WQI depict that none of them are fit for drinking except those of Pasawali and Garej pond, which to an extent, are satisfactory.

The WQI of surface and sub-surface water with regard to its utility in textile dyeing and printing units were considered. Results reveal that both surface and sub-surface water are unacceptable for use in such industries.

Excluding the point sources, the surface water of Bhadar valley in the pre-monsoon belong to satisfactory to poor water class for irrigational use. Like-wise, in the post-monsoon, by and large, all water belong to satisfactory category excepting those of Gondli nadi and Bhadar at Jetpur which are good; whereas south of Isra, it is of poor quality. For sub-surface water, except at Upleta and Ganod, water quality is good to satisfactory for irrigation, irrespective of seasons. In the coastal block, WQI for irrigation of the surface and sub-surface water are satisfactory in Garej, Nedhna, Jambu, sluice gate Navibandar, Segras and Paswali The rest are poor to unacceptable.

The quality of water for agricultural purpose based on the U.S. salinity diagram, Residual Sodium Carbonate (RSC) and Wilcox plots were examined. The U.S.salinity diagram exhibits that majority of the pre-monsoon surface water belong to C_3-S_1 type (good water), however, a few deviates and falls into the field of C_4-S_1, C_4-S_2, C_4-S_3, C_4-S_5 and C_5-S_1 type. Like-wise, all post-monsoon surface water are good except the point source of Derdi and Jetpur. Ground water of pre-monsoon indicates good quality from Khirasara to Upleta; and beyond Upleta they are moderate to unsuitable for irrigation, while, in the post-monsoon, ground water are generally good.

Pre-monsoon surface water based on RSC for irrigation are suitable from Karmali nadi to Sultanpur bridge and beyond Lunagiri, while, those from Derdi to Lunagiri are not. The surface water of the post-monsoon, except the point sources are safe. In the sub-surface water of the pre-monsoon, those from Upleta and Ganod are unsuitable, whereas, Dhoraji, south of Isra is marginal and the rest are safe. On the other hand, in the post-monsoon the ground water from Upleta is unsuitable, however, west of Warasara is moderate and rest all are safe for irrigation.

Wilcox plot (EC versus percent sodium) depicts that the surface water from the point sources in the pre and post monsoon are unsuitable, while the rest are good to permissible. The sub-surface water of Upleta, Ganod and Vegdi of pre-monsoon and Ganod of post-monsoon are unsuitable.

The surface water of the coastal region for the pre and post monsoon in the U.S. salinity diagram depicts water to be good from Garej and Garej pond while the rest are unsuitable for irrigation. Whereas the same season's sub-surface water from Nedhna is good; Kutiyana Paswali and Jambu are moderate and the rest are unsuitable. Based on RSC, excepting Nedhna ground water (marginal), and Bantwa sub-surface water (unsuitable), the remaining surface and sub-surface water are safe for irrigation in the pre-monsoon However, in the post-monsoon, Nedhna and Bantwa sub-surface water are of unsuitable class, while the remaining surface and ground water samples are safe. Wilcox plot for the surface and sub-surface water in the coastal region exhibits that the Garej and Garej pond (surface water) and Nedhna ground water are good to permissible and the rest of the surface and sub-surface water are unsuitable in the pre-monsoon season. But in the post-monsoon, Jambu and Nedhna (ground water) and Paswali, Segras and sluice gate Navibandar (surface water) are good to permissible, while the rest are unsuitable for irrigation.

The mechanism controlling the water chemistry in the coastal area for the surface and sub-surface water of pre and post monsoon were plotted by following Subramanian's diagram. This plot revealed that irrespective of the seasons, the surface and sub-surface water belong to rock dominance and evaporation dominance types.

Analytical data of the water analysed reflect high concentration of various parameters. WQI suggest that the water to be poor and unacceptable for potability from all the locations except a few. People in direct contact with the surface water of Bhadar have rashes on their skin causing irritation and uneasiness. The intake of these water have created a number of health hazards like throat pain, burning in the epigastric region, headache, bodyache, giddiness, appendicities, chronic neurological & kidney problem and cancer.

Prevalence of the aforesaid diseases , may be on account of dye industrial effluents' contamination or can be due to many other unknown reasons. Hence, an indepth study on socio-medicine along with clinical study is warranted to understand the real inter-relationship of water quality and diseases.

On account of this, division bench of Gujarat High Court directed the closure of all units, until treatment facilities are made available. Still, even today more than 1500 units are effectively functioning, when the area was visited by the author in April 1997.

It is desireable to have a sustainable development rather than complete closure of units, which has an annual turnover of Rs. 150 crore. In the light of the existing scenario in the valley, mitigatory procedures proposed to reduce the environmental degradation vis-a-vis Jetpur dye industrial pollution are:

- The existing effluent treatment plants (ETP) should be again functional
- More ETP should be erected and all units waste water should be channelized preferably by closed canals upto the ETP.
- Monitoring of the canal should be made mandatory.
- Washing units may be ear-marked within certain areas and their waste also to be send to the ETP
- It is advisable that after treatment, the water may be recycled.

The above mentioned recommendations are mainly related to the waste water disposal plan. The alreday contaminated aquifers have to be rectified. For this, discharge followed by recharge of the aquifers are essential, which may be conducted during pre-monsoon and monsoon time through recharge wells. This flushing method, if repeated, may reduce the effect of the contaminants from aquifers. However, the feasibility of the flushing methods have to be examined in details by considering other requirments of water.

In the coastal zone, problem of salinity may be reduced by taking appropriate measures such as:

- No excess of ground water draft
- Tidal regulatory gate should be erected at all inlets
- Rain harvesting practice should be employed.

COMPLIMENT - A

DYEING AND PRINTING

INTRODUCTION

Time immemorial, man has been fascinated by colours. With the advent of civilization this became an obsession and started getting reflected in clothes of various colours and designs as per his liking This process compelled him to look out for colour dyes

This transition from the natural dyes to the synthetic ones, has also taken place in the century old Jetpur dyeing and printing units of Saurashtra. In the proceeding paragraphs, the author has briefly explained how this dyeing industry functions. He has collected the first hand information from the dyeing and printing units of Jetpur during his field trip. This will enable the readers to understand the real problem of the Bhadar river valley.

DYES OF JETPUR

The dyes applied on clothes are:

a) Direct dyes - are neutral dyes, have good affinity towards cotton, easy to apply without mordants, colours are stable and fast to light.
b) Basic dyes - are sorts of colours base and require an acid mordant such as tannic acid, tartaric acid, and acetic acid, gives bright colour to the fabric.
c) Vat dyes - are not water soluble, but are made soluble by strong reducing agents like sodium hydrosulphite.
d) Sulphur dyes - contain sulphur compounds and are applied together with a suitable reducing agents like sodium sulphide followed by oxidations.
e) Azoic dyes - contain the azo- group (-N =N-) and are formed by applying two component Napthol and fast Base) on to the clothes.
f) Reactive dyes - are water soluble, contains chemically active groups which enters and form a part of cotton fibre (good affinity), has excellent wash fastness.

Jetpur units are generally utilizing the Remazol dyes - a variety of reactive dyes; but occasionally direct and vat dyes are also used. The selection of remazol dyes, is on account of its close affinity towards the cotton fibres and being water soluble. In addition to this, it is also having low cost.

There is no dye manufacturing factories in and around Jetpur, however, they procure them from Baroda, Ahmedabad, Surat and Mumbai. These dyes are available in the form of fine powder and has various shades of colour. At Jetpur, these fine dye powders are mixed with "Gaur Gum" [Gawar seed (botanical name - "Cyamopsis tetragonoloba", Shah, 1978, p. 200) powder made into a paste with water]. It is interesting to observe that the raw clothes are also coming from Ahmedabad, Surat and Mumbai.

DYEING AND PRINTING TECHNIQUES

Gujarat is famous for its "Bandhini Print" being one of the cultural dress of the people. Bandhini printing is labourious, involve many stages of processes. Besides this, 'block printing' and 'screen printing' are also done. Here, the author, has briefly described the techniques which are adopted in the dyeing and printing industries of Jetpur.

Way back, at Jetpur,during the dawn of printing time, Bandhini printing and the Block printing, mainly on cotton clothes were prevalent. Now-a-days screen printing is very common.

Bandhini Printing: Bandhini (Tie-knot method) is more labourious, wherein number of knots are made as per the design using strings and then dyes are applied. This process may be repeated till the required variety of colours and designs are achieved.

Block printing: On the contrary to the long process of Bandhini printing, the block printing technique is simple, fast and also can have any complicated designs. The designs are carved in the wooden blocks which are immersed in the dye and emborsed on the clothes.

Screen printing: Designs and pattern are made on the special synthetic screen. An advantage of this method is less man power, speedy work and cost effectiveness.

Working table:

The printing table is having a length of 10m to 12m, width 1.5m to 2m, and 2.5m height, kept slanting on any one side, which facilitate the working process. Before printing, this wooden table is coated with a thin layer of wax which helps in (i) to fix the clothes without shrinkage, (ii) to avoid the absorption of the dyes by the wood and (iii) to wash the table after printing.

Initially, the cotton cloth is placed on the table, the screen (design selected to print), is placed on one edge of the table and the dye selected is spread uniformly over the screen (Plate 1a), with the help of rubber whiper, so as to get the good print. This process is continued laterally till the complete length of the cloth is printed. If more than one colour is required, then a sequence of different screen opening are used by dyeing various combination of colours. After the printing, the clothes are dried in the shade (Plate 1b).

The dried dyed clothes are then passed through the silicate solution to enhance the quality of colour fixation within the cellulose of cotton fibre. However, the silicates does not enter or adhere onto the cotton fibre, but slowly on repetitive use is transformed into a solid waste.

The next procedure is the washing and processing unit. This process requires large open area and excess of water, therefore, it is generally called on sub-unit contract. Such units are conspicuous around Jetpur, located in the mid of the agricultural fields where sufficient quantity of water are drawn from the wells. No doubt, few units also function within the premises of the printing unit itself.

The washing procledure has two stages viz. the dyed clothes are boiled along with Glauber salt, common salt, hydrogen sulphate, dicromates in a boiler (Plate 1c). This helps i) in the fixation of dyes on to the clothes ii) the colour fastness and iii) light fastness. After boiling for about half an hour to one hour, the clothes are washed thoroughly in water and starched before drying (Plate 2a,b and c).The clothes are iron pressed and are dispatched to the market/customers. The washing and processing units are often of make-shift arrangement.

The overall consumption of dyes in each printing units varies, however, the absorption of the dyes by these cotton clothes range from 70% to 80 %. It reflects the total amount of dye left over on the table as well as in final washing process, which then is added into the streams as pollutant (Plate 3a and b), because of which the surface water of river Bhadar have turned coloured compared to the unaffected Bhadar dam water (Plate. 3c).

The dyeing and printing units are small scale to medium scale, distributed in and around Jetpur. At present there are more than 1500 units are effectively functioning, out of whih many may not have the official registration. This figure was gathered after the Gujarat High Court stay (1st August,1995) ordering closure of these units. Before the High Court order, there were more than 2,500 units functioning out of which roughly 1125 units are registered.

PLATE - 1

a) Picture showing the process of screen printing on cotton cloth in Jetpur.

b) Picture showing the drying process after printing in Jetpur

c) Picture shows boiler in which printed cloths are heated.
(Location : Near Panchpipla)

1a

1b

1c

PLATE - 2

a) Picture shows washing processes after treatment in the boiler
(Location : Near Panchpipla)

b) Picture shows starch being applied on the clothes.
(Location : Near Panchpipla)

c) Picture shows the drying on the clothes in open agricultural fields.
(Location : Near Panchpipla)

2a

2b

2c

PLATE - 3

a) Picture depicting the waste effluent water being discharged from the washing units in tothe streams.

b) Picture illustrating the breaching of lined canal and entry of effluents into the river Bhadar at Jetpur. (Lens facing the old railway bridge)

c) Various effluent water samples collected at different locations in and around Jetpur (along with a beaker containing clear water)


3a


3b


3c

QUALITATIVE ANALYTICAL PROCEDURES FOR WATER

The qualitative analysis of water samples were estimated by following the standard procedures given by American Public Health Association (APHA, 1980). In the proceeding paragraphs, a brief outline of these procedures are given

PHYSICAL PARAMETERS

ELECTRIC CONDUCTIVITY (E.C)

Conductance represents the ability of a substance to transmit electric current, help in determining the quality of dissolved substance in the solution E C is expressed in micromho/cm E C was determined using Mullar electronic equipment, England, Model E.-7566, 110-24 V

pH (ACIDITY-ALKALINITY)

pH of a solution is defined as "the negative logarithm to the base 10 of the hydrogen-ion activity" pH estimation was done with the help of pH meter (Elico make, model — Year Hyderabad)

SUSPENDED SOLIDS

200ml of well mixed sample was taken in a beaker. It was then filtered using the pre-weighted Whatman 44 filter paper The retained residue was oven dried and weighed The difference in weight was calculated and multiplied by the factor 5 and expressed in mg/l.

CHEMICAL PARAMETERS

CHLORIDE

Chlorides occur widely in water and are associated with Na ion. 20 ml of the sample was taken in the conical flask using a pipette 2 ml of 5 % potassium chromate [5 gms of K_2CrO_4 in 100 ml distilled water] was added to it The content was then titrated against 0.02 N $AgNO_3$ [3.4 gms of dried $AgNO_3$ (A.R) dissolved in distilled water to make one litre of solution], until a persistent red tinge end point appeared. The amount of chloride present was calculated using the following formula Is1

$$\text{Chloride, mg/l} = \frac{(\text{Xml} \times 0\ 02\ \text{N of } AgNO_3\ ) \times 1000 \times 35.5}{20\ \text{ml}}$$

where X = Burette reading

CALCIUM

20 ml of the sample was taken in a conical flask using a pipette 2 0 ml of NaOH solution [40 gm of NaOH in one litre of distilled water] was added Also 100 - 200 mg Murexide indicator [mixture of 0 2 gm of ammonium purporate and 100 gm NaCl (A R) grinded well], was added which changed the solution pink Then, it was titrated against 0 01 M EDTA solution [3 723 gm of disodium salt of EDTA in one litre distilled water] until the pink colour turns to purple. The amount of calcium in mg/l was computed using the following formula

$$\text{Calcium mg/l} = \frac{X \times 400\ 8}{20\ \text{ml}}$$

Where X = Volume of EDTA used

HARDNESS

Hardness may be classified as a) carbonate and non-carbonate hardness, b) calcium and magnesium hardness, and c) temporary and permanent hardness. Usually Hardness is measured as concentration of calcium and magnesium

20 ml of the sample was taken in the conical flask using a pipette 1 ml of buffer solution [Add 142 ml of NH_3 solution to 17 50 gms A R NH_4Cl and dilute it to 250 ml, solution has pH 10 0] was added to the sample When 100-200 mg of Erichrome Black T indicator [mix 0 4 gms Erichrome Black T indicator with 100 gms NaCl (A R) and grind, mixture looks light violet], the solution turned wine red The sample was titrated against 0 01 M EDTA solution [3.723 gms of disodium salt of EDTA dissolved in distilled water to prepare one litre of solution (0 01)] At end point colour changed from wine red to blue and the hardness was calculated using the formula

$$\text{Hardness as } CaCO_3 \text{ mg/l} = \frac{\text{ml of EDTA used} \times 1000}{20 \text{ ml}}$$

MAGNESIUM

With the help of volume of EDTA used in calcium and hardness estimation, the amount of magnesium present can be calculated by using the below mentioned formula

a) $$Mg^{++} \text{ mg/l} = \frac{(Y-X) \times 400\ 80}{\text{Volume of sample} \times 1\ 645}$$

Where Y = EDTA used in hardness determination
X = EDTA used in calcium determination for the same volume of sample

b) $$Mg^{++} \text{ mg/l} = \text{Total hardness (as mg/l } CaCO_3) - \text{calcium hardness (as mg/l } CaCO_3) \times 0\ 224$$

Where calcium hardness (as mg/l $CaCO_3$) = Ca mg/l x 2.497

NITRATE

0.7218 gm oven dried potassium nitrate (KNO_3) was dissolved in distilled water, made to one litre which gave the stock solution of nitrate; 1 ml = 100 μg NO_3^-- 50 ml of the stock solution was diluted to 500 ml to obtain the standard solution Various sets of standards (1ml, 1N HCl added to each) were prepared in Nesslers tube to calibrate the spectrophotometer (Model - Hitachi · 150-20) at 220 nm wavelength. Samples were also treated with 1N HCl to prevent interference from hydroxide and carbonate The concentrations of nitrate were read directly from the instrument.

OIL AND GREASE

Dissolved or emulsified oil and grease was extracted from water by intimate contact with Trichlorotrifluoroethane (TCTFE) TCTFE dissolves not only oil and grease but also other organic substances which prevailed in the water Further no solvent selectively dissolves only oil and grease

100 ml of the sample was taken in a separating funnel To it, 5 ml of HCl was added to acidify the sample to pH 2 30 ml TCTFE was added to the separating funnel and was vigorously shaked for 2 minutes and the layers were allowed to separate The solvent was drained through a filter paper containing few lumps of Na_2SO_4 into a evaporating dish Again the process was repeated by adding TCTFE so as to ensure complete removal of oil and grease The evaporating dish was placed on the water bath and cooled and weighed. The amount of oil and grease was calculated using the following formula

$$\text{mg/l oil and grease} = \frac{(A - B) \times 1000}{\text{ml of sample}}$$

where, A = weight of the evaporating dish with residue
B = weight of the evaporating dish

PHOSPHATE

219.5 mg anhydrous, KH_2PO_4, was dissolved in distilled water, made to one litre; 1.00 ml = 50 μg PO_4 - P, served as the standard solution To calibrate the spectophotometer (Model - Hitachi · 150-20), standard phosphate solution was diluted to 100 ml in Nessler tube, concentration of which ranged from 0 to 2 mg/l They were treated with 4 ml ammonium molybdate reagent [25 g $(NH_4)_6M_7O_{24}$ $4H_2O$ dissolved in 175 ml of distilled water 280 ml concentrated H_2SO_4 was added to 400 ml distilled water and allowed to cool. Molybdate solution was added to it, volume made to one litre] and 0.5 ml stannous chloride reagent (2.5 gm fresh $SnCl_2$. $2H_2O$ dissolved in 100 ml glycerol, heated on water bath and stirred to fasten dissolution). The sample were made acidic by adding 1N HCl 2 ml of acidified sample was diluted to 100 ml and 4 ml ammonium molybdate and 0.5 ml stannous chloride reagent were added. The concentration of phosphate in the samples were recorded from the spectrophotometer

SULPHATE

20 ml of sample was taken in a conical flask using a pipette 20 ml of $BaCl_2$, 0 01 M solution [24 42 gms of $BaCl_2$ dissolved in 100 ml of distilled water, gave 1 0 M solution 10 ml from it was taken and diluted to 1000 ml to get 0 01 M] was added to it, wherein $BaSO_4$ got precipitated 5-10 ml of buffer solution [Dissolve 17 50 gms of NH_4Cl (A R) in 142 ml concentrated NH_3 solution so that pH = 10 00] , and 100-200 gms of Erichrome Black - T indicator [Solochrome black + NaCl) were added, which turned the solution into wine red colour, and was titrated with 0 01 M EDTA [3 723 gms of EDTA in one litre distilled water] End point was noted as wine red colour changed to violet to blue.

BaCl, solution was standardised by titrating with 0 01 M EDTA solution [20 ml of 0 01 M $BaCl_2$ solution taken, to it 5-10 ml of buffer solution, 100-200 mgs Erichrome Black -T indicator were added] Solution turned wine red and was titrated against EDTA, the end point being the appearance of blue colour The volume in ml of EDTA used to standardise $BaCl_2$ is X

Volume of EDTA = 0 01 M $BaCl_2$ = X
Y = Volume of EDTA used in total hardness (Ca^{++} + Mg^{++})
Z = Volume of EDTA used for Ca^{++} + Mg^{++} + SO_4^{-}
Amount of sulphate present was calculated using the following formula

Volume of EDTA = X - (Z - Y) = X_1

$$SO_4 \text{ (mg/ltrs.)} = \frac{X_1 \times \text{Normality of EDTA} \times 96000}{20 \text{ ml}}$$

TOTAL ALKALINITY, CARBONATES AND BICARBONATES

Total alkalinity is the measure of the capacity of the water to neutralise a strong acid The alkalinity in water is generally imparted by the salts of carbonates, bicarbonates, phosphates, nitrates, borates, silicates etc. together with the hydroxyl ions in free state

20 ml of the sample was taken in the conical flask using a pipette 2 drops of phenolphthalein indicator (pH 8 3) was added to it If the solution remained colourless it indicated Phenolpthalein alkalinity (PA) is zero and was further proceeded by adding 2-3 drops of methyl orange indicator (pH 4 2 - 5.4) But if the colour of the solution turned pink on addition of phenolphthalein indicator, it was titrated with 0.01 N HCl, until the solution turned colourless The burette reading so obtained was for PA Further, 2-3 drops of methyl orange indicator was added in the same, the solution turned yellow It was titrated with 0 01 N HCl till yellow colour changed to pink The burette reading was

noted The total ml of HCl used, using both phenolphthalein and methyl orange, gave the burette reading for total alkalinity (T.A.) PA and TA as $CaCO_3$ mg/l were calculated using the following formula

$$\text{PA as } CaCO_3 \text{ mg/l} = \frac{(\text{A x Normality}) \text{ of HCl x } 1000 \text{ x } 50}{\text{ml of sample}}$$

$$\text{TA as } CaCo_3 \text{ mg/l} = \frac{(\text{B x Normality}) \text{ of HCl x } 1000 \text{ x } 50}{\text{ml of sample}}$$

Where A = ml of HCl with only phenolphthalein
B = ml of total HCl used with phenolphthalein and methyl orange

Concentration of carbonates, bicarbonates and hydroxyl ions were determined from the following table using data of PA and TA

Result of titration	OH alkalinity as $CaCO_3$	CO_3 alkalinity as $CaCO_3$	HCO_3 alkalinity as $CaCO_3$
P = 0	0	0	T
P < 1/2 T	0	2P	T - 2P
P = 1/2 T	0	2P	0
P > 1/2 T	2P - T	2(T - P)	0
P = T	T	0	0

Where, P = Phenolphthalein alkalinity and T = Total alkalinity

BIOLOGICAL PARAMETERS

BIOLOGICAL OXYGEN DEMAND (BOD)

Amount of oxygen required to biologically degrade the organic matter in water is termed as BOD It also measures the amount of oxygen used to oxidise inorganic material such as sulfides and ferrous ions

1 litre of distilled water was taken in a jar 1 ml each of ferric chloride [0 25 gms $FeCl_3$ $6H_2O$ dissolved and made to one litre], calcium chloride [2 75 gms $CaCl_2$ dissolved and made to one litre], magnesium sulphate [22 5 gms $MgSO_4$ $7H_2O$ dissolved and made to one litre] and phosphate buffer [8.5 gms KH_2PO_4, 21 75 gms K_2HPO_4, 33 4 gms Na_2HPO_4 $7H_2O$ and 1.7 gms NH4Cl dissolved and made to one litre] were added and aerated for one hour to prepare the "dilution water"

10 ml of the sample was taken and made to 1 litre by addition of "dilution water" It was filled in 3 BOD bottles (300 ml capacity each) Out of three, two were stoppered, made water tight, and kept in an incubator at 20°C for 5 days. In the third BOD bottle, 2 ml each $MnSO_4$, alkali azide were added and shaked The flocculus formed were allowed to settle, then 2 ml of H_2SO_4 was added It was titrated against 0 0125 N Sodium thiosulphate solution using starch as an indicator until the blue colour changed to colourless The value so obtained, was the dissolved oxygen of the first day The remaining two bottles underwent the same procedure on the fifth day to get the dissolved oxygen A blank BOD bottle was also kept, one analysed on the first day and the other two on the fifth day on the similar lines to find the dissolved oxygen in the "dilution water" BOD in mg/l was calculated as follows ·

$$\text{BOD mg/l} = \frac{\text{Difference of dissolved oxygen of the 5th and 1st day}}{\text{Fraction of sample used}}$$

CHEMICAL OXYGEN DEMAND (COD)

It measures the oxygen equivalent of the organic matter content of the sample that was susceptible to oxidation by a strong chemical oxidant.

2 ml of the sample was taken in a erlenmeyer flask 18 ml of distilled water, 10 ml $K_2Cr_2O_7$ [0 25 N; 12 259 gms potassium dichromate dried at 103°C for two hours, dissolved and diluted to one litre], 30 ml H_2SO_4 reagent [Ag_2SO_4 powder added to concentrated H_2SO_4 at the rate of 22 gms Ag_2SO_4 / 4 kg bottle, allowed to stand for 1 or 2 days to dissolve Ag_2SO_4] and 5 gms $HgSO_4$ were added The solution was condensed for one and half hour and little water was added through the condenser [300 mm Jacket Lie big, West or equivalent condenser] after putting off the burner The solution was allowed to cool and the amount in the flask was made to 140 ml using distilled water 2 to 3 drops of Ferroin indicator [1.485 gms 1, 10 - Phenonthroline monohydrate and 695 mg $FeSO_4$ $7H_2O$ dissolved in distilled water and amount made to 100 ml] was added in the flask and was titrated against 0 1 N Ferrous ammonium sulphate-FAS [98 gms $Fe(NH_4)_2(SO_4)_2$ $6H_2O$ dissolved in distilled water and 20 ml concentrated H_2SO_4 added to it. The stock solution so obtained, has Normality 0.25 N, diluted to get the required normality of 0.1 N], the end point was colour change from bluish green to maroon red A blank sample was run to determine the COD of the distilled water, wherein 20 ml of distilled water was taken in the erelenmeyer flask along with other reagents, the procedure remaining same.
COD in mg/l was determined using the following formula

$$\text{COD, mg/l} = \frac{(A - B) \times N \times 8000}{2\text{ml}}$$

where, A = Volume of FAS used for the blank, in ml
B = Volume of FAS used for the sample, in ml
N = Normality of FAS
2 = Volume of the sample taken for analysis

TRACE ELEMENTS

Trace elements were analysed using the Atomic Absorption Spectrophotometer Stock solution were prepared for individual elements and the instrument was calibrated using the standard solution prepared from the stock solution, of different concentration, fitting in the minimum optimum working range for each element. The stock solution for each element were prepared as suggested by APHA (1980) as follows ·

ALUMINIUM

1.0 gm aluminium metal dissolved in 20 ml of concentrated HCl by heating gently and diluted to one litre with distilled water or 17 584 gm aluminium potassium sulfate (Potassium alum), $AlK(SO_4)_2.12H_2O$, dissolved in 200 ml distilled water to which 1 5 ml concentrated HNO_3 was added and diluted to one litre, 1 0 ml = 1 0 mg Al

BORON

8 8190 gms Boric acid, $Na_2B_4O_7$ $10H_2O$, dissolved in one litre of distilled water, 1 0 ml = 1 0 mg B

CADMIUM

1 0 gm Cadmium metal was dissolved in a minimum volume of 1 1 HCl and diluted to one litre with distilled water, 1 0 ml = 1 0 mg Cd

CHROMIUM

2.828 gms anhydrous potassium dichromate($K_2Cr_2O_7$), dissolved in 200 ml distilled water, 1 5 ml concentrated HNO_3 added to it and diluted to one litre, 1 0 ml = 1 0 mg Cr

COPPER

1.0 gm copper metal dissolved in 15 ml of 1.1 HNO_3 and diluted to one litre; 1.0 ml = 1.0 mg Cu.

FLUORIDE

The stock fluoride solution was prepared by dissolving 221 0 mg anhydrous sodium fluoride, NaF in distilled water and volume was made to one litre; 1 ml = 100 µg F 100 ml of the stock solution was diluted to 1,000 ml with distilled water, 1 ml 8= 10 µg F Different concentration of fluoride standards were prepared (50 ml each), to which 5.0 ml acid-zirconyl- SPANDS reagent (133 mg Zirconyl chloride octahydrate, $ZrOCl_2$ $8H_2O$, dissolved in 25 ml distilled water 350 ml concentrated HCl was added to it and diluted to 500ml with distilled water 958 mg SPANDS, sodium 2-(para-sulfophenylazo)-1,8 -dihydroxy-3, 6-napthalene disulfonate) dissolved and diluted to 500 ml with distilled water Equal volume of zirconyl-acid and SPANDS were mixed) were added to calibrate the spectrphotometer at a wavelength of 520 nm The samples diluted to 50 0 ml were also treated with 5 0 ml acid- zirconyl- SPANDS reagent; and the concentration were recorded from the spectrophotometer

IRON

1 0 gm iron wire dissolved in 50 ml 1 1 HNO_3 and diluted to one litre with distilled water, 1 0 ml = 1 0 mg Fe

LEAD

1.598 gm lead nitrate, $Pb(NO_3)_2$, dissolved in 200 ml distilled water and 1 5 ml concentrated HNO_3 added to it, diluted to one litre with distilled water, 1.0 ml = 1 0 mg Pb

MANGANESE

3 076 gm manganous sulfate, $MnSO_4$ H_2O, dissolved in 200 ml distilled water and 1 5 ml concentrated HNO_3 added to it, diluted to one litre, 1 0 ml = 1 0 mg Mn.

NICKEL

1 273 gm nickel oxide, NiO, dissolved in a minimum volume of 10% (v/v) HCl and diluted to one litre with distilled water; 1.0 ml = 1 0 mg Ni

STRONTIUM

2.415 gms strontium nitrate, $Sr(NO_3)_2$, dissolved in one litre of 1% (v/v) HNO_3, 1.0 ml = 1 0 mg Sr

ZINC

1 0 gm zinc metal dissolved in 20 ml 1 1 HCl and diluted to one litre with distilled water, 1 0 ml = 1 0 mg Zn

COMPLIMENT - C

STANDARDS FOR POTABLE WATER

Parameters	W.H.O. (1971)		I.C.M.R. (1975)		Indian standard IS-10500(1983)	
	H	M	H	M	H	M
Biological						
BOD	-	-	-	-	3 0	3 0
COD	-	-	-	-	-	-
Chemical						
Arsenic	-	0.05	0.05	0 20	0 05	-
Calcium	75	200	75	200	75	200
Cadmium	-	0 01	-	0 05	0 01	-
Chromium	-	-	-	-	0 05	-
Chloride	200	600	250	1000	250	1000
Cobalt	-	-	-	-	-	-
Copper	0 05	1.50	1.0	3.00	0 05	1 50
Flouride	0.06-0 09	0.8-1 7	1.0	-	0.6-1.2	1 5
Iron	0 05	1.5	0.30	1.0	0 30	1 0
Lead	-	0 10	-	0.10	0 10	-
Magnesium	30	150	50	150	30	100
Manganese	0 1	1 0	0 10	0 5	0 1	0 5
Nickel	-	-	0.10	-	-	-
Nitrate	-	45	20	50	45	-
Oil & Grease	0.01	0 3	-	-	0 01	-
Phosphate	-	-	-	-	-	-
Sulphate	200	400	200	400	150	400
Strontium	-	-	-	-	-	-
Total Hardness	100	500	300	600	300	600
Total Dissolved solids	500	1500	500	1500	500	1500
Zinc	5.0	15.0	5 0	-	5 0	15 0
Physical						
pH	7 0-8.5	6.5-9 2	7 0-8.5	6.5-9.2	6 5-8.5	6 5-9 2
EC (micromho/cm)	-	1600	800	2400	800	2400

Note : H = Highest desirable limit
M = Maximum permissible limit
All values accept pH and EC are expressed in mg/litre