CHAPTER 1

INTRODUCTION

1.1 Role of Water in Students’ Life

School is a socializing institution, which stimulates learning environment and positive changes. Students are the changing agents. Hence, it ensures generational change in the adoption of the health and hygiene behaviour [1]. Giving safe drinking water to the populace especially the students is the prime responsibility of our government. In United Nations Conference on Sustainable Development, UN Secretary General, Ban Ki-moon gave a special address on “Water for life 2005-2015” on 28th July 2010. "The children who have no clean water to drink, the women who fear for their safety, and the young people who have no chance to receive a decent education have a right to do better, and we have a responsibility to do better. All people have the right for the safe drinking water, sanitation, shelter and basic services."

- Ban Ki-moon, UN Secretary General

Through resolution 64/292, the United Nations General Assembly recognized the sufficient, safe, acceptable and affordable drinking water with proper sanitation for each and every human being in the developing countries.

It has been reported earlier that the knowledge exists with significant correlation between safe drinking water and academic achievements in schools in Ghana Sierra, Leone and South Africa and also explained the need and purpose of the potable water [2]. Drinking water does not only help to resolve the problems of obesity, nutrient and health, it also helps to improve academic achievements in schools. A study reports that school going
children can suffer lead concentration from school drinking water [3]. The study shows the importance of health, nutrient and sanitation about school going age students.

Another research work reports that the drinking water quality deterioration in households of students with high illness is the reason for absenteeism [4]. The dehydration contributes to symptoms of mild dehydration include thirst, headache, poor concentration, lethargy, chronic dehydration, irritability, constipation, urinary tract infections, acute appendicitis, and cardiovascular disease [5]. In India, the central and the state government play a crucial role in providing drinking water for all schools, especially in rural areas with high density population [6]. A recent study of young adults found that mental performance decrease by 10% when they are thirsty. Without proper knowledge of safe drinking water, most of the students have the habit of having their drinking water in dirty water bottles, water withdrawal without hand wash, poor domestic hygiene, dipping hands in water and no washing of container.

1.2 Reasons for Water Pollution in Schools

The reasons for water contamination in schools are given as follows:

- Water in the rocky areas contains minerals which are harmful to the growth of bones, teeth, kidney and liver.
- Water tanks are never kept clean.
- The sewage in the schools and hostels affect the ground level water.
- The poor maintenance of kitchen and its smoke affects the quality of drinking water.
- The improper dumping of the wastage in laboratories affects the water source.
- The particles of the corroded water supplying pipes mixing with the drinking water, which leads to the spread of disease like allergy and intestinal problems.
1.3 Causes of Polluted Drinking Water

One of the main causes of low state of health in India at the time of independence, in early 1950s was lack of safe water supply and sanitation. The decade of 1981-90 was recognized as the International drinking water supply and sanitation decade. Over the thirty years, the village people and the students totally depend on ground water for drinking purpose. Some of the schools are located in the centers of the villages and some are located outside the villages which are nearer to agricultural lands. Unfortunately drinking water supply has become contaminated which may be due to over-use of limited water sources, uncleaned kitchen wastages during the preparation of Noon meals for students, toilets in schools, fertilizers, pesticides and septic tanks. Due to inadequate infrastructure such as lack of fencing or compound wall of the schools, people in the vicinity use the school buildings, during vacation, for their personal activities.

Deprived section of the society consumes contaminated water and takes ill periodically, often resulting in epidemics. Water and sanitation related diseases that are affecting students include dysentery, diarrhoea, hepatitis, polio and trachoma. Female teachers and students spent more time in schools and encounter the challenges of managing their menses period and within the school environment where washing facilities are not provide with the privacy required. The ill-health of the students is one of the reasons for the absence and dropout of students from the schools. It makes a psychological problem and creates a stress among peer group, parents, teachers and students. Lost working days, missed educational opportunities, official and unofficial health care costs, draining of family resources affect the green economy of the society. Sometimes it leads to suicidal attempt of the students. In recent years more works have been carried out on the severe impact of water quality parameters in drinking water sources. The water quality parameters are classified as aesthetic, nutrient and toxic.
1.4 Study Area

In this study, 30 physico-chemical parameters have been analyzed in the drinking water sources of Government Kellar Reclamation Higher Secondary Schools (GKHSS) in Tamilnadu, India during POM and PRM seasons of the year 2010-12.

1.4.1 Kellar Reclamation Schools

This work was carried out by collecting water samples from 24 GKHSS situated in three districts - Madurai, Theni and Dindigul. These schools are unique in the sense that they have a long history from the time of the colonial rule.

1.4.2 The Birth of Kellar Reclamation Schools

Many historians postulate that Kellar means brave people and black. In olden days black dravidians were stated as Kalla to state their bravery. Important Kellar sub caste is Piramalaikallar. They are highly conservative and have preserved their customs and traditions even today. They are also believed to be the oldest inhabitants of the Tamil country with reports of their presence going back to Tamil literacy works of the 4th century B.C. They are residing mainly in the districts of Madurai, Dindigul and Theni.

It is claimed that the said community has been declared as a Most Backward Class among the socio, educational and economical stages. The government has created a project in the name of Kellar Reclamation Scheme. This scheme was started for the welfare of the people belonging to the Piramalaikallar community in Madurai, Dindigul, and Theni Districts. In the above three districts, under the Kellar reclamation scheme, there are 285 schools in which 24 are higher secondary schools and 50,000 student are studying. Apart from these, 48 hostels are also running under the control of the scheme and there are
1700 teachers working in these schools. In 1963, Kallar Reclamation Scheme was brought under the control of Adi Dravidar and Backward classes welfare department and special rules were also framed known as Adi dravidar welfare subordinate service rules, under the control of The District Revenue officer, Department of Kallar Reclamation, Madurai.

In 1919, the whole of Piramalaikallar community came under the scan of criminal Tribes Act. According to the Act, the members of Kallar community had to register themselves by submitting their thumb impression at the respective police stations. In addition, male members above 16 years of age had to spend their nights in police stations and get police permission to visit their relatives. As a result, villagers who resented being labeled as criminals disobeyed the order. In the year 1920, seventeen persons were killed gruesomely by the British police force for agitating against the fingerprint act. The people affected by the notorious Fingerprint Act had been included in the scheduled tribes list. The pillar at Perungamanallur in Madurai district tells the tale of a little known tragedy.

In a bid to provide education to children belonging to this community, the British established the Kallar Reclamation Schools in 1921 and introduced the Kallar Common Fund and Kallar Panchayat System. After the establishment of Kallar Reclamation Schools, the socio, economic and educational status of the Piramalaikallars have increased too many fold. Although a great many of the members are still agriculturalists, many have progressed up to the social leader as doctors, engineers, entrepreneurs, politicians, lecturers and civil servants. Large number of people serves the Indian Army and Tamilnadu police department.
1.4.3 Recent Developments in Kallar Reclamation Schools

Under the scheme of Kallar Reclamation, 285 Kallar Reclamation schools are functioning under the control of Most Backward Classes and Denotified Communities Welfare department for the educational upliftment of Piramalai Kallars in Madurai, Theni and Dindigul Districts where they are living predominantly. The total strength of the kallar reclamation schools is given in the following Table. 1.1.

1.4.4 Hostels

There are 48 hostels under the Control of Special Deputy Collector (Kallar Reclamation), Madurai, for giving boarding and lodging for poor students. The details of the Hostels in three districts are given in the Table 1.2

In a bid to encourage the enrolment of girls students of this particular community in government schools, Government of Tamilnadu has announced that Madurai district is all set to get its first Kallar reclamation school exclusively for girls students at Chekanurani. State officials have already begun work to start the construction of the building in the precincts of the existing GKHSS in rural Checkanurani. Two separate Heads of Department are functioning to administrate and educational activities [7].

1.5 Historical and Seasonal Variations of Sampling Stations

1.5.1 Madurai District

Madurai is located at 9.93°N 78.12°E. It has an average elevation of 101 meters. The city of Madurai lies on the flat and fertile plain of the river Vaigai, which runs in the northwest-southeast direction through the city, dividing it into two almost equal halves. The Sirumalai and Nagamalai hills lie to the north and west of Madurai. The land in and around Madurai is utilized largely for agricultural activity, which is fostered by the Periyar Dam.
Table 1.1 Details of the Students’ Strength in Kallar Reclamation Schools

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Category of Schools</th>
<th>Number of Schools</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
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<tbody>
<tr>
<td>1</td>
<td>Higher Secondary Schools</td>
<td>24</td>
<td>9,087</td>
<td>6,592</td>
<td>15,679</td>
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<td>2</td>
<td>High Schools</td>
<td>21</td>
<td>2,804</td>
<td>2,484</td>
<td>5288</td>
</tr>
<tr>
<td>3</td>
<td>Middle Schools</td>
<td>28</td>
<td>2,198</td>
<td>2,080</td>
<td>4278</td>
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<tr>
<td>4</td>
<td>Elementary Schools</td>
<td>212</td>
<td>7,391</td>
<td>6,918</td>
<td>14,309</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>285</strong></td>
<td><strong>21,480</strong></td>
<td><strong>18,074</strong></td>
<td><strong>39,554</strong></td>
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</tbody>
</table>

Table 1.2 Details of Hostels

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of District</th>
<th>Details of Hostels</th>
<th>Admitted strength</th>
<th>Govt. Building</th>
<th>Private Building</th>
<th>Total No. of Buildings</th>
<th>Total No. of Teachers</th>
</tr>
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<tr>
<td>1</td>
<td>Madurai</td>
<td>15 7</td>
<td>3,513</td>
<td>13</td>
<td>9</td>
<td>22</td>
<td>102</td>
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<td>2</td>
<td>Dindigul</td>
<td>5 2</td>
<td>570</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>29</td>
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<tr>
<td>3</td>
<td>Theni</td>
<td>14 5</td>
<td>1,210</td>
<td>5</td>
<td>14</td>
<td>19</td>
<td>74</td>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>34 14</strong></td>
<td><strong>5,293</strong></td>
<td><strong>20</strong></td>
<td><strong>28</strong></td>
<td><strong>48</strong></td>
<td><strong>205</strong></td>
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Madurai lies southeast of the Western Ghats, and the surrounding region occupies the plains of South India and contains several mountain spurs. The soil type in central Madurai is predominantly clay loam, while red loam and black cotton types are widely prevalent in the outer fringes of the city. Paddy is the major crop, followed by pulses, millet, oil seed, cotton and sugarcane. The location map of the study area in Madurai district is given in Fig. 1.1.

The municipal corporation of Madurai has an area of 147.977 km$^2$. Madurai is hot and dry for eight months of the year. Cold winds are experienced during February and March as in the neighbouring Dindigul. The hottest months are from March to July. The city experiences a moderate climate from August to October, tempered by heavy rain and thundershowers, and a cool climate from November to February. Fog and dew are rare occurring only during the winter season. Being equidistant from mountains and the sea, it experiences similar monsoon pattern with Northeast monsoon and Southwest monsoon, with the former providing more rain during October to December. The average annual rainfall for the Madurai district is about 85.76 cm. Temperatures during summer generally reach a maximum of 40 °C and a minimum of 26.3 °C, although temperatures up to 42 °C are not uncommon. Winter temperatures range between 29.6 °C and 18 °C. A study based on the data available with the Indian Meteorological Department on Madurai over a period of 62 years indicate rising trend in atmospheric temperature over Madurai city, attributed to urbanization, growth of vehicles and industrial activity. The maximum temperature of 42 °C for the decade of 2001-2010 was recorded during 2004-2010. The average ground water level for POM and PRM from 1991-2010 in Madurai district is given in Fig. 1.2.
Fig. 1.1 Location map of the study area in Madurai District
### Average Ground water level for POM and PRM from 1991-2010 in Madurai District

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<tr>
<td>2</td>
<td>Post Monsoon Ground water</td>
<td>5.4</td>
<td>5.5</td>
<td>5.5</td>
<td>5.7</td>
<td>6.0</td>
<td>7.9</td>
<td>5.5</td>
<td>2.7</td>
<td>3.5</td>
<td>5.2</td>
<td>6.0</td>
<td>7.3</td>
<td>8.2</td>
<td>7.3</td>
<td>3.0</td>
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<td>3.5</td>
<td>4.7</td>
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<td>Level in m (January)</td>
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<tr>
<td>3</td>
<td>Pre Monsoon Ground water</td>
<td>7.4</td>
<td>6.0</td>
<td>8.1</td>
<td>8.4</td>
<td>5.7</td>
<td>7.0</td>
<td>10.5</td>
<td>7.2</td>
<td>6.4</td>
<td>5.5</td>
<td>7.1</td>
<td>7.8</td>
<td>8.6</td>
<td>10.0</td>
<td>11.1</td>
<td>7.3</td>
<td>5.4</td>
<td>7.2</td>
<td>4.9</td>
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<td>Level in m (May)</td>
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**Fig. 1.2** Average Ground water level for POM and PRM from 1991-2010 in Madurai District
1.5.2 Theni District

Theni is a district of Tamil Nadu state in South India. The district is divided into two natural divisions: The hilly areas constituted by parts of the three taluks Periyakulam, Uthamapalayam and Andipatti with thick vegetation and perennial streams from the hills on the western side and Cumbum valley which lies in Uthamapalayam taluk. The district receives rainfall under the influence of both southwest and northeast monsoon. Normal annual rainfall is of the order of 791.2 mm out of which 47% (375.5) received during Northeast monsoon and 22% (172.7) is received during Southwest monsoon. The mean daily minimum temperature varies from 20.9 °C (January) to 26.3 °C (May) and mean daily maximum temperature varies from 29.7 °C (December) to 37.5 °C (May). The evaporation values vary from 80 mm to 325 mm. The climatological data have been furnished by Department of Economics and Statistics, Government of Tamil Nadu. The location map of the study area in Theni district is given in Fig. 1.3. The average ground water level for POM and PRM from 1991-2010 in Theni district is given in Fig. 1.4

1.5.3 Dindigul District

Dindigul is the headquarters of Dindigul district and is an important growing city in the Tamilnadu state. Dindigul area is a hard rock, drought-prone region and is situated in the Dindigul district of Tamilnadu, India. It lies in between 10°13’-10°26’ north latitudes and 77°53’ - 78°01’ east longitudes. It covers an area of about 240 km². The highest elevation in the hilly area (Sirumalai hill) is of order of 1350 m.

But it varies from 360 m in southern portions to 240 m in the Northern parts of the area. Runoff from precipitation within the basin ends in small streams flowing towards main river Kodaganar.
Fig. 1.3 Location map of the study area in Theni District
**Fig. 1.4** Average Ground water level for POM and PRM from 1991-2010 in Theni District
Fig. 1.5 Location map of Dindigul District
Fig. 1.6 Average Ground water level for POM and PRM from 1991-2010 in Dindigul District
The average annual rainfall is in the order of 915.5 mm during the year of 2010-2011. Dindigul is one of the important places for its tannery units. It has more than 80 tannery units in and around the city and nearly 50 units are under processing of leather. It is the fact that the processing of leather requires large amount of freshwater along with various chemicals. Groundwater is the main source of drinking water in Dindigul. The leather industry in and around the Dindigul city pollute both surface and groundwater by discharging their wastes. The location map of the study area in Dindigul district is given in Fig. 1.5. The average ground water level for POM and PRM from 1991-2010 in Dindigul district is given in Fig. 1.6.

1.5.4 Sources of Drinking Water in Kallar Reclamation Schools

Drinking water is one of the most important constituents for healthy living of human society. The ground water depends on the rock type, seasonal variations, and soil type. In the last three decades, the exploitation of ground water increased in many folds but vagaries of monsoon due to change in climatic condition reduced the rainfall at many places resulting into reduction in surface runoff and replenishment of the depleting ground water aquifer. Reduction in rainfall due to change in climatic condition not only reduces the recharge to the aquifer to meet the demand for domestic and agricultural demand but also enhances the pollution level in ground water. When pollution level increases, it affects the entire system of the environment. In all of our study areas, the sources of drinking water are ground water from bore wells, hand pumps and Panchayat Union supplied over tank water through iron pipelines as shown in Fig. 1.7 to 1.9.
Fig. 1.7. Photos showing a few study areas in Madurai District

(a) Thummakundu  
(b) Vikkiramangalam  
(c) Nattamangalam  
(d) Checkanurani
Fig. 1.8 Photos showing a few study areas in Theni District:

(a) Rajadhani Hostel    (b) Karunakkanmuthanpatti
(c) Uthamapuram        (d) Rajadhani
Fig. 1.9  Photos showing a few study areas in Dindigul District

(a) Kondamanaiickenpatti   (b) Vilampatti
(c) AnaiPatti       (d) Kamupillaichattram
1.6 Trident Effect on Drinking Water

The purity of ground water, which is used for drinking purpose, is affected by three important factors such as seasonal variations, geological nature and anthropogenic (man-made pollution) activities. The vast majority of surface water on the planet is neither potable (fit for drinking) nor toxic. Approximately 25% of the world’s population has no access to potable water. Madurai, Theni and Dindigul districts are facing serious public health disasters due to drinking water contamination. The contaminants such as geogenic, anthropogenic and seasonal variations show trident effect on ground water for drinking purpose of the students.

Geological formations of Western Ghats and the ground lithology explain the nature of rock type granite, fluorapatyte, gypsum, limestone, dolamite, bauxite and cryolite. This rock type shows the impact of Na$^+$, K$^+$, Ca$^{2+}$, Mg$^{2+}$, SO$_4^{2-}$, Cl$^-$, F$^-$, and TH and interprets the richest mineral belt of the sub-continent consisting of iron ores, coal, lead, copper, nickel and zinc. Groundwater flow, surface runoff, interflow, pumped in and out flows, siliceous materials dissolution of soil constituents, mainly carbonates, have strong effect on the concentration of pollutants. High intake of heavy metal results in damage to kidney, liver, intestine and carcinogenic and non-carcinogenic diseases on human health. Problems related to toxic amount of heavy metals are metabolic disorder and Epigastria burning. High concentrations of fluoride (>0.5 mg/L) in water leads to the consequences of diseases like fluorosis, dental caries, osteosclerosis, thyroid, kidney dysfunction and cardio vascular problems [8]. Excess amount of calcium and magnesium leads to kidney and heart diseases. Cd leads to itay-ityay and As leads to keratosis, black foot disease, cardio vascular disease and typical skin lung and bladder cancers [9].
BOD, COD, DO, pH, EC, TDS, microorganisms, organic matters, soluble salts, nutrient pollutants, acidic nature of sewage, nitrates and fecal bacteria, agricultural run-off along with fertilizers, village population, school students strength, untreated waste water, improper locations of toilets, greenhouse gases, radioactive contaminants, chemical pollutants and other toxic materials from industrial processes are the major anthropogenic factors. It leads to epidemics and chronic diseases and cause typhoid, tuberculosis asbestosis, a fatal disease due to asbestosis contamination and lung cancer. High Concentration of nitrate causes blue baby syndrome and Methaemoglobinaemia. Drinking water is supplied through iron pipelines, which are associated with inadequate plumbing systems. It leads to turbidity which affects the taste, odor and color of the drinking water. The corrosion scale deposits reduce the hydraulic capacity of the pipes. It leads to the growth of microorganisms in water.

1.7 Fluoride in Drinking Water

The occurrence of fluoride in drinking water is mainly due to natural or geogenic contamination. As rainwater filtrates through the soil and reaches the water table, it can dissolve partly certain components of bedrock. The fluoride content of ground water can thus originate from the dissolution of fluorine bearing minerals in the bedrock. Fluoride contamination is a function of many factors such as availability and solubility of fluorine bearing minerals, temperature, pH, concentration of calcium and bicarbonate ions in water. In recent years, there has been an increased interest in fluoride research because excess concentration of fluoride in ground water causes adverse impact on human health. In order to mitigate excess fluoride in water, it is essential to determine and monitor the cause and factor of enrichment of fluoride concentration in drinking water in time and space.
1.7.1 Sources of Fluoride Exposure

Fluoridated toothpaste, some pharmaceutical medications and food / beverages lead to exposure to fluoride which contain fumigants and rodenticides. Industrial exposure including aluminum smelting, glass etching, and some manufacturing processes also can be attributed to fluoride exposure. Fluoridated water includes occupational exposure to sodium fluoride in water treatment and extra ordinary usage of beverages.

1.7.2 Effects of Chronic Fluoride/Fluorine Exposure

Weight loss, chronic fatigue not alleviated by rest, general weakness, depression, headaches, bone, joint and muscle pain, muscle spasms, brittle bones and teeth, tinnitus, anemia, acidosis, reddish spots on skin, slight bleeding from nose lining, blurred vision, dizziness, poor balance, numbness, tingling of termites, depression, difficulty concentrating, loss of mental alertness, nervousness, excessive thirst, knee inflammation, frequent urination, nausea, diarrhea, constipation, blood in stools, flatulence, abdominal pain, damage to internal organs, and to cellular biochemistry & thyroid functioning [10-13].

1.7.3 Routes of Entry and Storage of Fluoride

- Fluorides can enter the body through inhalation of gases and vapors, through swallowing, and through skin absorption.

- Fluorides can be stored in bones and teeth, and any tissues of the body

1.7.4 Risk of Fluoride-rich Groundwater

In high concentrations, soluble fluoride salts are toxic and skin or eye contact with high concentrations of many fluoride salts is dangerous. Referring to a common salt of fluoride, sodium fluoride (NaF), the lethal dose for most adult humans is estimated to be
5 to 10 g (which is equivalent to 32 to 64 mg/kg elemental fluoride/kg body weight). Ingestion of fluoride can produce gastrointestinal discomfort at doses at least 15 to 20 times lower (0.2–0.3 mg/kg) than lethal doses. Although helpful for dental health in low dosage, chronic exposure to fluoride in large amounts interferes with bone formation. In this way, the greatest examples of fluoride poisoning arise from fluoride-rich ground water [14-18]. The problem of high concentration of fluoride in India was first reported in Nellore District in 1937 in Andhra Pradesh. In 1991, it was reported that drinking water in 13 of India’s 32 states and Union territories contain naturally high concentrations of F−. The most seriously affected areas are in the states of Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Tamilnadu, Kerala, Madhya Pradesh. The highest F− concentration in ground water reported in India is 48 mg/L in the Rewary District of Haryana state. Assam being the most recently identified state with high F− levels in drinking water, which is associated with endemic fluorosis. Dental fluorosis is endemic in 14 states and in 1,50,000 villages in India [19-20]. Geology is also a key factor in fluoride contamination of groundwater [21]. In particular, high concentrations of fluoride often occur in magmatic rocks. In addition, the release of calcium from rocks plays an important role since fluoride can be precipitated in the form of calcium fluoride.

Indian Standard specifies (IS1 0500:1991) desirable and permissible limits of fluoride in drinking water as 1.0 and 1.5 mg/L. High levels of fluoride in drinking water (>1.5 mg/L) leads to dental and skeletal fluorosis as shown in Fig. 1.10.

Problem is severe where ground water is the major source of drinking water especially granitic and gneissic rocks underlie the study area. The faults and fractures in these rock formations are occupied by fluoride bearing minerals. Common fluorine bearing minerals
Fig. 1.10 Dental and *skeletal fluorosis*
are fluorite, apatite, amphiboles, cryolite and micas that tend to occur in crystalline (granite, granitic gneiss) and sedimentary (limestone and sandstone) rocks. Fluoride from these minerals leaches to the groundwater.

1.7.5 Scope of the Work

In this work, quality of water in 24 Government Kallar Reclamation Higher Secondary Schools has been analyzed in post and pre monsoon seasons of the years 2010 to 2012. A special emphasis has been given to identifying fluoride annoying zones in the study area and identification and evaluation of a low cost natural adsorbent for defluoridation. This is the first attempt to analyze around thirty parameters in the drinking water sources of twenty four Higher Secondary schools of Government Kallar Reclamation Department, in Tamilnadu, India. The overall scope of the present research work is depicted in the following Figure 1.11.

1.7.6 Main Objectives of the Research

- Evaluation of physico-chemical parameters of drinking water supply in 24 Government Kallar Higher Secondary Schools in Madurai, Theni and Dindigul districts in Tamilnadu during POM and PRM seasons during the consecutive years of 2010 – 2012 and comparison of tested parameters with WHO standards.

- Development of a statistical approach, viz. Cluster analysis on the analyzed water quality parameters to assess the water quality type and degree of contamination.

- Identification of polluted areas with special emphasis on fluoride annoying zones.

- Identification and evaluation of a low cost natural adsorbent for the removal of fluoride from drinking water.
**Scope of the Work**

**Evaluation of drinking water Quality in Tamilnadu Government Kallar Reclamation Higher Secondary Schools**

- **Madurai**
  1. Checknarani
  2. Melaurappanur
  3. Kappalur
  4. Nattamangalam
  5. Pappapatti
  6. Vikkiramangalam
  7. Vellaimalaipatti
  8. Vadakkampatti
  9. Thummakundu
  10. Thadayampatti
  11. Melakkal
  12. Ayyappanaickenpatti

- **Theni**
  1. Karunakkamuthanpatti
  2. Vellaiammalpuram
  3. Uthamapuram
  4. Melagudalur
  5. MuthaiyanChettipatti
  6. PuthuPatti
  7. RajaDhani
  8. Ethakovil

- **Dindigul**
  1. Kondamaickenpatti
  2. Vilampatti
  3. Anaipatti
  4. KamupillaiChatram

**Physico-chemical Parameters**

1. pH  
2. Temperature  
3. Colour  
4. Odour  
5. EC  
6. TDS  
7. TA  
8. TH  
9. Chloride  
10. Sulphate  
11. Fluoride  
12. Bicarbonate  
13. Calcium  
14. Magnesium  
15. Sodium  
16. Potassium  
17. Silicate  
18. Nitrate  
19. DO  
20. BOD  
21. COD  
22. Turbidity  
23. Boron  
24. Nitrite  
25. Hardness  
26. Copper  
27. Zinc  
28. Iron  
29. Nickel  
30. Chromium

- **Post Monsoon 2010-12**
- **Pre Monsoon 2010-12**

**Statistical Tools**

Hierarchical Cluster Analysis

- Fluoride annoying schools
- Defluoridation

**Fig. 1.11** Flowchart showing the scope of the research work
References


