Final Technical Report

on

STUDIES ON POPULATION DYNAMICS, ITS IMPACT TO ENVIRONMENTAL RESOURCES AND STRATEGIC MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF CHANDEL DISTRICT, MANIPUR

(Vide U.G.C. Order No. F.No. 43-330/2014(SR) dt. 24th Sep. 2015)

ज्ञान-विज्ञान विमुक्तये

Submitted to

UNIVERSITY GRANTS COMMISSION
NEW DELHI

Under the Scheme of: Major Research Project (MRP)

Submitted by

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1. INTRODUCTION

The rapid population growth in Chandel District, a tribal district alarmingly threatening the environment through the expansion of urban area, the uncontrolled growth of urbanization and the destruction of natural habits. Further, the environmental degradation due to growth of population adversely affects the natural and environmental deterioration was facing the challenges of sustainable development of the area. Furthermore, population growth and the resultant human activities generate pressure to the natural and man-made environment (U.N., 1993). Overshoot population causes overloaded impacts on the environment primarily through the use of natural resources and production of wastes that inseparably overburden to environmental stress. Chandel district one of the hilly district coverage maximum by forest, the probable lungs of the state, desperate to deplete and pollutes local resources which are livelihood of present and future generations. Though the relationship is complexity, population size and growth tend to expand and accelerate these human impacts on the environment. Ever increasing world population is not a new issue. Thomas Malthus, in 1798 worried whether a food supply that was increasing linearly could keep up, with a population that was growing geometrically that blaze flashed the new conceptual aspect of human population on earth.

Chandel district one of the hill district of Manipur state with a total geographical area of 3,31,300 hectares lies in between 23.49^0 and 24.28^0 North latitude and 94.09^0 to $94.3\ 1^0$ East longitude in the south-eastern part of the state. The border district of the state neighbors Myanmar on the south, Ukhrul district on the east, Churachandpur district on the south and west, and Thoubal district on the north. It is about 64 km from Imphal, the state capital. The district was formerly known as Tengnoupal district and the district came into existence on 13^{th} May 1974. The district is inhabited by several communities with about 20 tribes and is sparsely populated. Anal, Lamkang, Kukis, Moyon, Monsang, Chothe, Thadou, Paite and Maring are the prominent tribes scattered all over the district. There are also other religious communities such as Meitei and Muslims in small numbers as compared to these tribes. Non-Manipuri communities like Tamils, Bengalis, Punjabis and Biharis are also in the district.

2. OBJECTIVES

For achieving the target goal, the following objectives have been laid down:-

i) To investigate the trend of population dynamics in the Chandel district, Manipur.

ii) To survey, collect and detect the status of daily use drinking and household water from the normally used natural water sources of the district.

iii) To explore the exploitation of natural soil and land resources.

iv) To determine the sustainability of the available natural resources.

v) To establish the predictable formulae of environmental deterioration of natural resources by impact of population dynamics.

3. METHODOLOGY

Surveys being to produce information for a goal, to describe, to compare and to predict attitudes, opinions, values and behavior based on what people say or see and what is contained in records and their activities (Fink, 1995: Yadava and Yadava, 1995), the present survey's aims fixed to the goal. The present work of surveying mainly adopt to suitable probability samplings like (i) simple random sampling (ii) stratified random sampling (iii) systematic sampling (iv) cluster sampling and non-probability sampling like (i) convenience sampling (ii) snowfall sampling (iii) quote sampling (iv) focus groups.

Data categorized under two groups (P.V. Young) viz., (1) documentary viz. books, report of surveys, memories, accounts of travel, historical accounts, official published data and other unpublished record; and (2) field sources e.g., direct observation, information from the informants, information from witnesses etc. have accounted as per intrinsic demand for the objectives of the goal.

For estimating the population dynamics two types of method has been formulated following Odum, (1971).

1. Arithmetic scale

$$N_t = N_o e^{rt} \qquad (I)$$

where,

N_t Number at time t

N_o Number at time zero

e = base of natural logarithms

r = growth rate

2. Logarithmic scale:

$$InN_t = InN_o + rt \quad (11)$$

$$\therefore r = \frac{InNt - InNo}{t}$$

where,

N_o = Number at time zero

N_t = Number at time t

e = base of natural logarithms

r = growth rate

After computation, the drawn growth dynamic curves were compared with well-developed population dynamic graph following Odum (1971).

For determination of simple forecast of future population growth, the exponential of equation (1) have adopted.

Water samples of river flowing at Chandel district ponds, wells, springs etc. that normally used for household purposes including drinking have to collect at monthly intervals for a total period of three years (i.e. from October 2015 to September 2018) for the examination of selected physico-chemical and biological parameters. The samples have to analyses by adopting standard methods for the examination of water as prescribed by Trivedy and Goel (1986), APHA (1998) and Khopkar (1995).

The water quality index (WQI) has to calculate following Brown *et al.*, (1972).

$$WQI = \Sigma q_n w_n / w_n$$

Where,

n= water quality parameters and quality rating (qn) corresponding to n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value.

The q_n is calculated by using the following expression

$$q_n = 100(V_n - V_{10})/(S_n - V_{10})$$

where,

q_n = Quality rating for the n^{th} water quality parameter.

V_n = estimated value of n^{th} parameter at a given sampling stations.

S_n= standard permissible value of nth parameter.

V_{10}=ideal value of n^{th} parameter in pure water.

All the ideal values of n^{th} parameter (V_{IO}) are taken as zero for the drinking water except for pH= 7.0 and dissolved oxygen =14.6 mg/L.

Quality rating for p^H is calculated following equation of $q_{pH,}$

$$q_{pH} = 100 [(V_{pH} - 7.0) / (8.5 - 7.0)]$$

Where,

V_{pH}= observed value of pH

Quality rating for Dissolved oxygen is calculated following equation of q_{Do}

$$q_{DO} = 100 [(V_{DO} - 14.6)/(5 - 14.6)]$$

Where,

V_{DO} measured value of dissolved oxygen

The unit weights (w_n) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

$$W_n = K / S_n$$

Where,

w_n= unit weight for n^{th} parameters,

S_n =Standard value n^{th} parameters

K= constant for proportionality

For erosion of soil, the erosivity of rainfall or rainstorm, a function of its intensity and duration and of the mass, diameter and velocity of the rain drops has been accorded following Wischmeier and Smith (1978) in metric units.

For determination of K.E,

K.E. = 210.3 + 89 $\log_{10}$ I.

where,

I = rainfall intensity ($cmhr^{-1}$)

K.E. = Kinetic Energy ($Mt\ ha^{-1}cm^{-1}$)

Thus, for determination of Erosivility index KE x 1_{30}

$EI_{30}=\frac{KE \times 1_{30}}{100}$

EI_{30}= Erosivity index,

I_{30} = max 30 min rainfall intensity of storm.

Erodibility, the resistance of this soil to both detachment and transport has been computed following Wischmeier and Mannering (1969) using for

Erodibitity index (K) = Soil loss per unit of EI_{30}

Soil loss due erosion by adoption of universal soil loss equation following Wischmeier and Smith (1962),

E=RKLSCP

Where, E = mean annual soil loss ($tac^{-l}y^{-1}$)

R = rainfall erosivity

K = soil erodibility index

L = slope length

S = slope deepness

C=Crop Factor

P = conversion practice

Physical properties of soil have to study by Universal method.

$$R=\frac{El_{30}}{100}$$

$$LS = \frac{\sqrt{L}}{22.13}(0\text{-}065 + 0.0455 + 0.0065S2)$$

For determination of sustainable development on the capabilities of resources in the Chandel district, under mentioned formulae have to be adopted following Rees (1992).

1. Ecologically productive land per capita

$$EPLC \text{ (in Ha)} = \frac{A(in\ Ha)}{TP\ (in\ Nos)}$$

where, A = Area in hectares

TP = Total population in numbers

2. Ecologically deficit land per capita

EDLC (in Ha) = FP-EPLC

where, EPLC = Ecologically productive land per capita (in Ha)

FP =2 Ha (since India belongs to (2-3) Ha footprint)

3. Ecologically deficit land per capita, EDLC in percentage available in decades

$$=\frac{EDLC\ (in\ Ha)}{EPLC\ (in\ Ha)} \text{ x } 100$$

4. Ecologically deficit land per capita, EDLC in percentage available in annum

$$=\frac{EDLC\ (in\ Ha)}{EPLC\ (in\ Ha)} \text{ x } 100$$

The three criteria of “sustainable”, “critical” and “destructive” have been put framed for all human activities like population increase, economic development, deforestation rate, forest coverage, agricultural development and urbanization following Murai (2005).

For analysis of social environmental status in districts, sampling houses have to be selected randomly and house-to house census have to undertaken by using questionnaire and schedule (Fink, 1995; Converse, 1987; Fink. 1993; Fowler, 1993; Frey, 1989).

4. EXPERIMENTAL RESULTS

4.1. Investigation on the Trend of Population Dynamics in the Chandel District, Manipur

The population growth of Chandel district in 1951 recorded 24,049 persons having density of 7 per sq.km. with corresponding logarithmic scale as 10.11 and arithmetic scale as 24,146. On the next decade i.e., 1961 population was increased with 3,630 (13.11%) persons (i.e., 24,049 to 27,679), the corresponding logarithmic scale as 10.51 and arithmetic scale as 36979 with a density of 8 persons per sq. km. In 1971, the population was increased with 11,044 (28.52%) persons (i.e., 27,679 to 38,723), the corresponding logarithmic scale as 11 persons. On the next decade i.e., 1981, the population was increased with 17,721 (31.39%) persons (i.e., 38,723 to 56,444), the corresponding logarithmic scale as 11.81 and 1,34,675 as arithmetic scale having a density of 17 persons per sq. km. In the year 1991, the population of Chandel district recorded 71,014 persons which is increased 14, 570 (20.51%) persons from the population of 1981 with corresponding logarithmic scale as 12,33 and 22,6463 as arithmetic scale with a density of 21 persons. The population of the district recorded 1,18,327 persons with a density of 35 persons and corresponding logarithmic scale as 13.13 and 5,04, 428 as arithmetic scale in the year 2001. On the next decade, i.e., in 2011, the population was increased 25,701 persons from the population of 2001 with a density of 43 persons, the corresponding logarithmic scale as 13.61 and 8, 20, 527 as arithmetic scale (Table 4.1.1).The data were display in Fig. 4.1.1a & b.

Table 4.1.1: Population Growth Dynamics of Chandel District (1951-2011) in Logarithmic and Arithmetic Scale

Year	Population (Nos.)	Decadal Variation (Nos.)	Decadal Variation (Nos.)	Density per sq.km.	Logarithmic scale	Arithmetic scale
1951	24,049	-	-	7	10.11	24,746
1961	27,679	3,630	13.11	8	10.51	36,979
1971	33,723	11,044	28.52	11	11.14	69,159
1981	56,444	17,721	31.39	17	11.81	1,34,675
1991	71,014	14,570	20.51	21	12.33	2,26,463
2001	1,48,327	47,313	39.98	35	13.13	5,04,428
2011	1,44,028	25,701	17.84	43	13.61	8,20,527

Source: Statistical abstract of Manipur, 2004

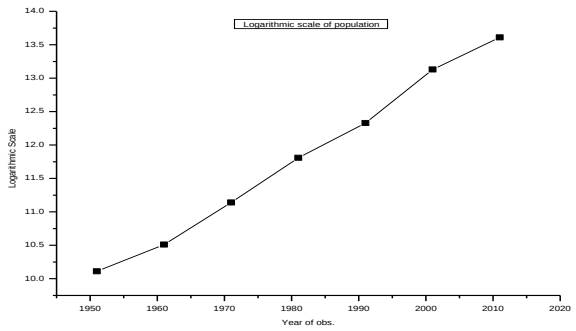

Fig. 4.1.1.a: Population Growth Dynamics of Chandel District (1951-2011) in Logarithmic Scale

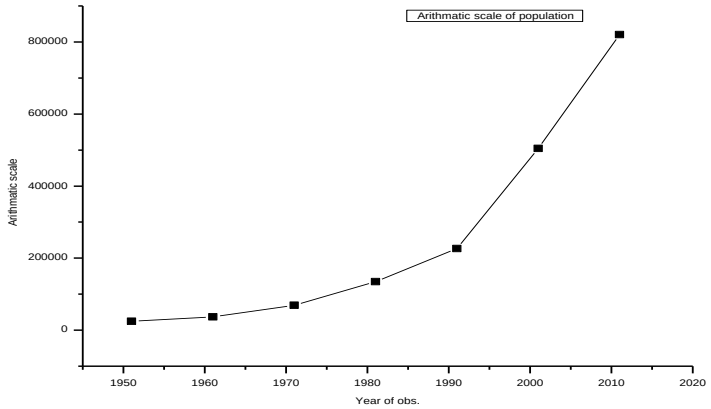

Fig. 4.1.1b: Population Growth Dynamics of Chandel District (1951-2011) in Arithmetic Scale

Table 4.1.1a revealed the population of Chandel district since 1951 to 2011 at an interval of 10 years with logarithmic and arithmetic values, indicates a serious pressure to the environment and it resources. Fig.4.1.1.a depict the graphical illustration of growth dynamics by representation of direct population numbers with initiation from 24.0 thousands at 1951 rises with and grew up to 27.6, 33.7, 56.4, 71.0 thousands at 1961, 1971, 1981 and 1991 and grew up to 1.1 lakhs at 2001 and 1.4 lakhs at 2011 with an increase of 3.6, 11.0, 17.7, 14.5, 47.3 at 1951 to 1961, 1961 to 1971, 1971 to 1981, 1981 to 1991, 1991 to 2001 and with decrease of 25.7 at 2001 to 2011. Even though the graph line is short, it indicates the growth pattern due to significant increase of population increase of population occurred in the district since 1951 to 2011. The finding was in agreement with that of other workers in different part of the country (Blacker, 1947; Thompson, 1929). Further, the finding clearly shows the population grew increasing, an unavoidable pressure to the nature, natural resources and land area.

Fig. 4.1.1.b depicts the exponential growth rate of Chandel district in a J. shaped curved representing the growing of population slowly. As population size increases, the growth rate also increases which means larger the population becomes, the faster it grows. The finding was in concordance with that of other workers (Birch, 1948; Bongaarts, 1998). Hence, the works to be followed under the present trend of growth rate have to be a close look as nucleus on population for better utilities and prompt success.

The calculated projected population of Chandel district was 1,56,037; 1,74,892; 1,93,747 persons in 2022, 2033, 2044 respectively according to arithmetic growth of population. By Odum's the projected population was 1,92,421 in 2022; 2,57,234 in 2033 and 3,43,650 in 2044. The mean projected population of Chandel district was 1,74,229 in 2022; 2,16,063 in 2033 and 2,68,698 in 2044. (Table 4.1.2) and graphically displayed in Fig. 4.1.2.

Table 4.1.2 Projected population of Chandel District for 2022, 2033 and 2044 years

Projected Year	Projected Population (Nos.)		Mean Projected Population
	By Arithmetic growth	Bu Odum's population	
2022	1,56,037	1,92,421	1,74,229
2033	1,74,892	2,57,234	2,16,063
2044	1,93,747	3,43,650	2,68,638

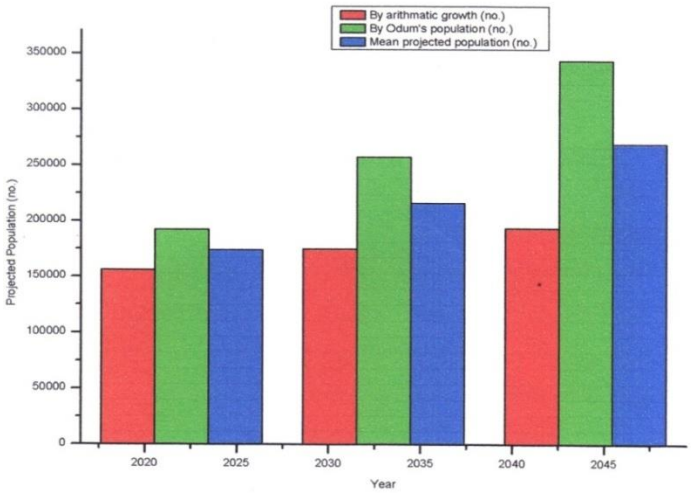

Fig. 4.1.2: Projected population of Chandel District for 2022, 2033 and 2044 years

Table 4.1.2 depicts the projected population of Chandel district base on arithmetic growth and Odum's population with a mean projected population for the year 2022, 2033, 2044. The mean projected population will be 1.7 lakhs at 2022 year, 2.1 lakhs at 2033 and 2.6 lakhs at 2044. The finding emphasized the heavy presence of population on the Chandel district during the forthcoming 3 decades of periods. Dittgen (2000) opined that the quality of population prediction depends on the quality of knowledge of past evolution in the demographic factors and on the capacity to forecast their future evolution.

4.2. Exploration on the status of daily used Drinking and Household Water sources including natural water resources of the Chandel District

Chandel district have five (5) sub-division viz., Machi, Tengnoupal, Chandel, Chakpikarong and Khenjoy. Machi sub-division has 70 nos. of village with 4069 nos. of households. Out of these households, 1320 households used from Tap water, 175 households, from well, 57 households from hand pump, 25 households from tube well, 601 households from pond and 180 households from other sources. Tengnoupal sub-division has 97 villages with 8271 households. Out of these households, 1392 households used water from tap water, 2823 households from Tube well, 1330 households from spring, 1562 households from river, 772 households from pond and 9 households from other sources. Chandel sub-division has 98 villages having 6767 nos. of households. Out of 6767 households, 1858 households used water from tap water for their drinking as well as domestic used. The number of household use from well, hand pump, tube well, spring, river and other sources was 320 households, 370 households, 35 households, 1112 households, 2309 households, 720 households and 43 households respectively. Chakpikarong sub-division has 133 villages with 9990 households. Out of these household, the number of households used water from tap water, well, hand pump, tube well, spring, river, pond and other sources were 990, 590, 1548, 58, 2280, 3867, 571 and 86 households respectively. And 5^{th} sub-division i.e., Khenjoy have 56 villages with 3088 households. Out of 3088 households, 730 households used water from tap water, 423 households from well, 170 households from hand pump, 28 households from tube well, 509 households from spring, 761 households from river, 420 households from pond and 47 households from other sources (Table 4.2.1). It is graphically portrayed in Fig. 4.2.1.

Table 4.2.1: Sources of water for household activity, Chandel District

Name of the Sub-Division	Total no.of villages (Nos.)	Total of Household (Nos.)	Total of water for household activity, Chandel District							
			Tap water	Well	Handpump	Tube well	Spring	River	Pond	Others
Machi	70	4069	1320	175	57	5	601	991	760	180
Tengnoupal	97	8271	1392	2823	276	107	1330	1562	772	9
Chandel	98	6767	1858	320	370	35	1112	2309	720	43
***Chakpikarong**	133	9990	990	590	1548	58	2280	3867	571	86
Khenjoy	56	3088	730	423	170	28	509	761	420	47

Before declaration of Tengnoupal District (dated 8th December 2016)

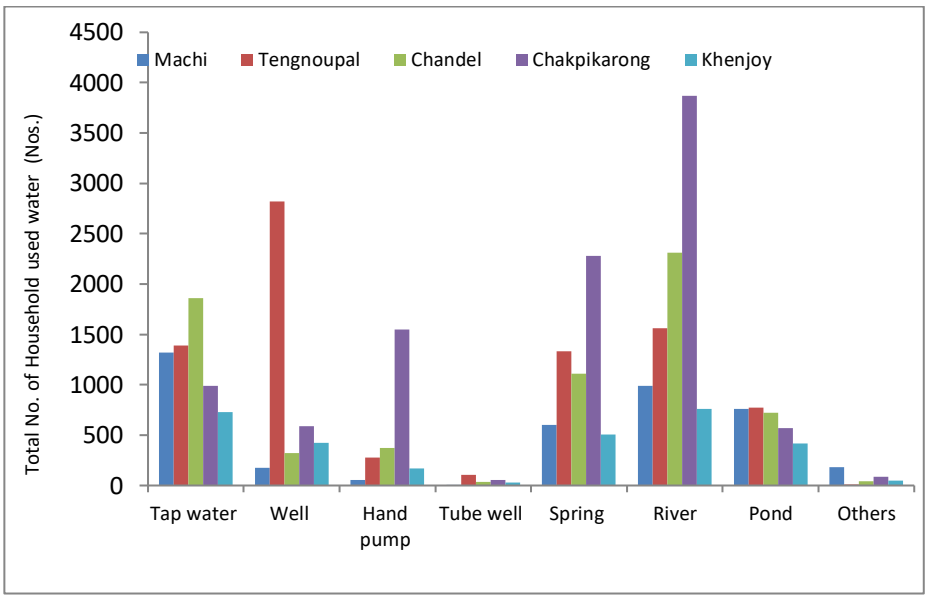

Fig. 4.2.1 Number of households which used water from different sources in Chandel District

Table 4.2.1 recorded the total number of villages with number of household located at the five (5) sub-divisions like Machi, Tengnoupal, Chandel, Chakpikarong and Khenjoy at Chandel district. Machi sub-division has only 70 villages with 4069 households. The main source of water in this sub-division was from tap water (1320 households) river (991 household), pond (760 households), spring (601 household), wells (175 households) and tube well (5 households) and others (180 households). Out of these five sub-division, Chakpikarong sub-division have highest number of villages i.e., 133 villages and followed and followed by 98 villages in Chandel, 97 villages in Tengnoupal sub-division, 70 villages in Machi sub-division and only 56 villages at Khenjoy sub-division. These five subdivisions recorded 454 villages in the Chandel

district with a total household of 32,185 numbers. In Machi sub-division, majority of the household perceive water sources from the tap water, Tengnoupal sub-division from the well water, Chandel sub-division from the river water, Chakpikarong from the river water and Khenjoy sub-division from the river water. The present finding highlights that out of these five sub-divisions Chandel sub-division, Chakpikarong sub-division and Khenjoy sub-division mainly use river water for their domestic as well as irrigation purposes. The finding was in corroborative with the results of other workers on different places (Shaban and Sharma, 2007; Bajpai and Bhandari, 2001).

Fig 4.2.1 depicts the graphical representation of number of households which used water from different sources such as tap water, well, hand pump, tube well, spring, rivers, ponds and others in the five sub-divisions of Chandel district. The finding highlight the rapid increase of population in Chandel district is making people more dependent on it leading to a rapid decline in ground water table. Delhi, Hyderabad and Kanpur are suitable examples in this regard (Soni, 2003).

The present work was divided into three parts as initial pre-field survey was carried out for identifying water collection sampling stations, secondly as field work, water samples were collected from identifying sampling station and lastly as post field interpretation, collected samples were analysed in laboratory and compilation of data. The water samples were collected by using pre-sterilized BOD bottles and pre-sterilized plastic bottles from each study sites like, tap water, well, hand pump, tube well, spring, rivers (Maha river, Chakpi river, Machi river)and pond etc. which were the main sources of drinking as well as household purposes for the people of the Chandel district. A total of 30 water samples were collected from three different spots each once in a month over a period of three year i.e., October 2015 to September 2018. All samples were labelled properly. Some parameters like temperature, turbidity, pH and dissolved oxygen were measured on site. The samples were analysed for following physico-chemical and biological parameters like temperature (^{0}C), turbidity (NTU), pH, dissolved oxygen (mg/1), free carbon dioxide (mg/1), biological oxygen demand (mg/1), total hardness (mg/1), calcium (mg/1), magnesium (mg/1) and faecal coliform (mg/1).

The selected 10 (ten) physico-chemical and biological parameters of the tap water sample were analysed during October 2015 to September 2016 in Table 4.2.2.a, October 2016 to September 2017 in table 4.2.2.b and October 2017 to September 2018 in Table 4.2.2.c. The graphical representations were displayed for respective table at Fig. 4.2.2.a to 4.2.2.c.

The water temperature of tap water ranged between 18.7°C (January) to 23.8°C (June).The turbidity was observed 4.6 NTU (February) as minimum and 7.4 NTU (October) as maximum. The p^H value of the water ranged between 5.9 (November) to 9.6 (March). The higher D.O. was observed in October 7.9mg/l and lower in July 3.9 mg/l. The free CO_2 was observed 45.01·.mg/l in February as minimum and 7.9 mg/l in November as maximum. The maximum in B.O.D. was observed in November (8.6 mg/1) and minimum in May (4.8mg/l). The total hardness ranged between 8.7 mg/1 in November to 18.6 mg/l in March. The calcium concentration was found to be higher in January (24.3 mg/1) and lower in November 2016 and March 2017 (10.8 mg/1). The magnesium was observed 05 mg/1 in November as minimum and 3.3 mg/1 in October16 and January 2017 as maximum. The total fecal coliform ranged between 47.9 mg/1 (Sept.) to 55.0 mg/l (January). The data were displayed in Table 4.2.2.a and graphically represented in Fig. 4.2.2 a.

Table 4.2.2.a: Analysis Physico –chemical and biological parameters of the water of tap water, Chandel District (Oct 2015 to Sept. 2016)

Parameters (Unit)	**Oct. 15**	**Nov. 15**	**Dec. 15**	**Jan. 16**	**Feb. 16**	**Mar. 16**	**Apr. 16**	**May 16**	**June 16**	**Jul. 16**	**Aug. 16**	**Sep. 16**
Temp. (^{0}C)	22.8	22.6	20.2	19.9	19.6	19.9	21.6	22.5	22.6	23.1	23.0	22.9
Turbidity (NTU)	7.3	6.3	6.4	6.8	4.8	5.8	5.9	5.7	5.6	5.5	5.7	5.8
pH	6.2	6.0	7.2	6.9	7.33.8	9.8	8.7	6.4	6.8	7.9	7.4	6.4
D.O.(mg/l)	7.8	6.5	6.5	7.8	4.9	4.8	4.8	3.7	3.7	3.3	5.2	4.4
Free CO_2(mg/l)	7.7	7.8	6.8	6.7	5.8	7.4	6.9	6.8	6.3	5.8	5.9	5.9
B.O.D. (mg/l)	8.2	8.8	8.4	7.8	17.8	5.4	5.2	5.0	5.4	5.9	6.0	5.7
Total Hardness (mg/l)	10.1	8.9	8.6	6.7	10.9	18.9	17.0	15.8	16.5	18.0	18.2	17.8
Calcium (mg/l)	24.4	10.8	12.4	10.6	1.6	10.9	12.0	11.9	12.9	12.7	12.8	11.9
Magnesium (mg/l)	3.4	0.4	0.9	3.5	1.6	1.9	1.2	0.9	0.8	1.2	1.3	1.4
Faecal Coliform (mg/l)	48.0	52.2	54.5	55.2	51.0	51.3	52.6	52.8	51.8	50.7	50.8	52.5

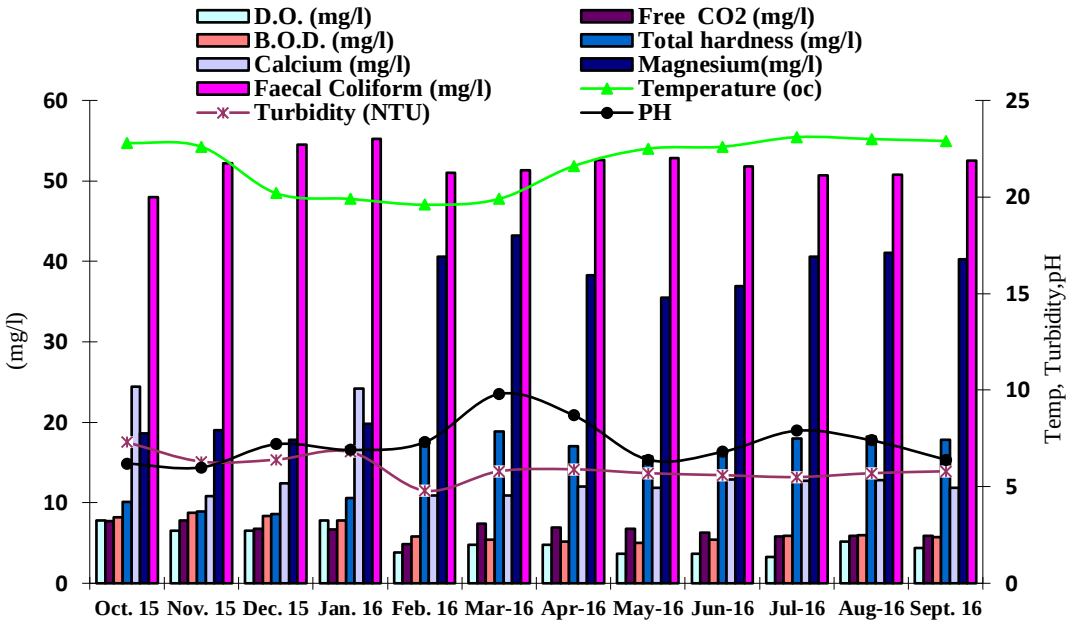

Fig. 4.2.2.a : Analysis Physico- chemical and biological parameters oif the water of tap water, Chandel district during Oct 2015 to Sept. 2016

Table 4.2.2.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The water temperature of tap water ranged between 18.7°C (January) to 23.8°C (June). The turbidity was observed 4.6 NTU (February) as minimum and 7.4 NTU (October) as maximum. The p^H value of the water ranged between 5.9 (November) to 9.6 (March). The higher D.O. was observed in October 7.9mg/l and lower in July 3.9 mg/l. The free CO_2 was observed 45.01.mg/l in February as minimum and 7.9 mg/l in November as maximum. The maximum in B.O.D. was observed in November (8.6 mg/1) and minimum in May (4.8mg/l). The total hardness ranged between 8.7 mg/1 in November to 18.6 mg/l in March. The calcium concentration was found to be higher in January (24.3 mg/1) and lower in November 2016 and March 2017 (10.8 mg/1). The magnesium was observed 05 mg/1 in November as minimum and 3.3 mg/1 in October16 and January 2017 as maximum. The total fecal coliform ranged between 47.9 mg/1 (Sept.) to 55.0 mg/l (January).

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Table 4.2.2.b: Analysis Physico –chemical and biological parameters of the water of tap water, Chandel District (Oct. 2016 to Sept. 2017)

Parameters (Units)	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temp. (^{0}C)	21.7	22.9	20.8	18.7	18.8	21.4	21.4	22.8	23.8	23.5	23.7	22.6
Turbidity (NTU)	7.4	6.2	6.3	6.9	4.6	5.2	5.4	5.6	5.4	5.2	5.9	5.8
pH	6.0	5.9	7.3	6.7	7.2	9.6	8.9	6.2	6.6	7.7	7.2	6.1
D.O.(mg/l)	7.9	6.4	6.6	7.6	4.0	4.9	4.7	4.1	4.0	3.9	5.0	4.1
Free CO_2 (mg/l)	7.8	7.9	6.4	6.3	5.0	7.6	7.0	6.7	6.2	5.9	6.0	6.0
B.O.D. (mg/l)	8.4	8.6	8.2	7.9	5.6	5.6	5.0	4.8	5.6	5.7	6.8	5.5
Total Hardness (mg/l)	10.4	8.7	8.8	10.4	17.4	18.6	16.8	16.0	16.3	17.8	18.0	17.6
Calcium (mg/l)	24.2	10.8	12.2	24.3	10.7	10.8	12.3	11.7	12.6	12.6	12.6	11.7
Magnesium (mg/l)	3.3	0.5	0.8	3.3	1.6	1.8	1.0	1.0	0.8	1.2	1.3	1.4
Faecal Coliform (mg/l)	48.1	51.8	53.8	55.0	49.8	51.1	52.4	52.5	51.6	51.9	51.9	47.9

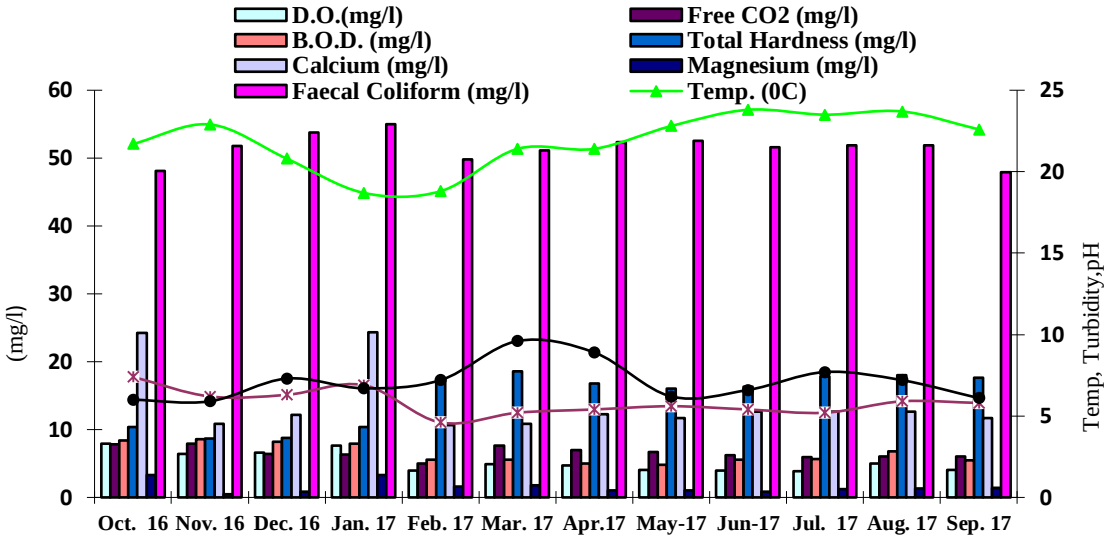

Fig. 4.2.2.b. Analysis Physico - chemical and biological parameters of the water of tap water, Chandel District (Oct. 2016 to Sept. 2017)

Table 4.2.2.b depicted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of tap water ranged between 18.7°C (January) to 23.8°C (June).The turbidity was observed 4.6NTU (February) as minimum and7.4 NTU (October) as maximum. The p^H value of the water ranged between 5.9 (November) to 9.6 (March). The higher D.O. was observed in October 7.9mg/l and lower in July 3.9mg/l. The free CO_2 was observed 45.01'.mg/l in February as minimum and 7.9mg/l in November as maximum. The maximum in B.O.D. was observed in November (8.6mg/1) and minimum in May (4.8mg/l). The total hardness ranged between 8.7mg/1 in November to 18.6mg/l in March. The calcium concentration was found to be higher in January (24.3mg/1) and lower in November 2016 and March 2017 (10.8mg/1). The magnesium was observed 05 mg/1 in November as minimum and 3.3 mg/1 in October16 and January 2017 as maximum. The total fecal coliform ranged between 47.9 mg/1 (Sept.) to 55.0mg/l (January).

The water temperature of tap water ranged between 19.0°C (February) to 24.2°C (August). The turbidity was observed 4.7NTU (February) as minimum and7.3NTU (October) as maximum. The p^H value of the water ranged between 6.3 (September and

October) to 9.4 (March). The higher D.O. was observed in October 7.7mg/l and lower in June 3.7mg/l. The free CO_2 was observed 5.2mg/l in February as minimum and 7.7mg/l in November as maximum. The maxim in B.O.D. was observed in November (8.7mg/1) and minimum in May (4.9mg/l). The total hardness ranged between 8.6mg/1 in December to 18.4mg/l in April. The calcium concentration was found to be higher in February (24.2mg/1) and lower in October (8.0mg/1). The magnesium was observed 0.5mg/1 in October and November as minimum and 3.3mg/1 in February as maximum. The total fecal coliform ranged between 48.2 mg/1 (October and September) to 54.8mg/l (January). The data were displayed in Table 4.2.2.c and graphically represented in Fig. 4.2.2.c.

Table 4.2.2.c: Analysis Physico–chemical and biological parameters of the water of tap water, Chandel District (Oct. 2017 to Sept. 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	20.8	22.7	21.2	19.2	19.0	21.7	21.6	22.6	23.6	23.7	24.2	22.4
Turbidity (NTU)	7.3	6.4	6.5	6.7	4.7	5.2	5.1	5.8	5.5	5.4	5.6	5.5
pH	6.3	6.4	7.1	6.4	7.0	9.4	8.7	6.5	5.8	7.8	7.0	6.3
D.O.(mg/l)	7.7	6.2	6.3	7.5	3.8	4.7	4.6	3.8	3.7	4.2	5.5	4.4
Free CO_2 (mg/l)	7.6	7.7	6.1	6.0	5.2	7.4	6.8	6.8	6.3	6.1	6.4	6.8
B.O.D. (mg/l)	8.5	8.7	8.0	7.4	6.0	5.8	5.2	4.9	5.7	5.4	6.9	5.7
Total Hardness (mg/l)	10.3	8.6	8.6	10.6	16.6	17.2	18.4	17.0	16.5	17.2	18.3	16.4
Calcium (mg/l)	8.0	11.0	12.4	24.0	24.2	11.0	11.2	12.1	11.5	12.3	12.8	11.0
Magnesium (mg/l)	0.5	0.5	0.9	3.2	3.3	1.5	1.7	1.1	1.2	1.1	1.3	1.3
Faecal Coliform (mg/l)	48.2	51.9	53.9	54.8	49.7	51.3	50.9	52.3	52.1	50.1	52.4	48.2

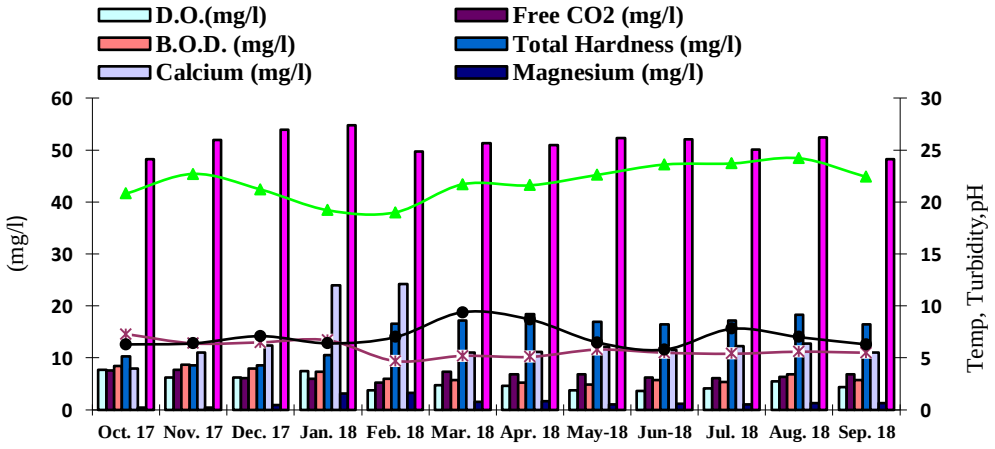

Fig. 4.2.2.c Analysis Physico –chemical and biological parameters of the water of tap water, Chandel District (Oct. 2017 to Sept. 2018)

Table 4.2.2.c highlighted the various physic-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The water temperature of tap water ranged between 19.0°C (February) to 24.2°C (August). The turbidity was observed 4.7NTU (February) as minimum and7.3NTU (October) as maximum. The p^H value of the water ranged between 6.3 (September and October) to 9.4 (March). The higher D.O. was observed in October 7.7mg/l and lower in June 3.7mg/l. The free CO_2 was observed 5.2mg/l in February as minimum and 7.7mg/l in November as maximum. The maxim in B.O.D. was observed in November (8.7mg/1) and minimum in May (4.9mg/l). The total hardness ranged between 8.6mg/1 in December to 18.4mg/l in April. The calcium concentration was found to be higher in February (24.2mg/1) and lower in October (8.0mg/1). The magnesium was observed 0.5mg/1 in October and November as minimum and 3.3mg/1 in February as maximum. The total fecal coliform ranged between 48.2 mg/1 (October and September) to 54.8mg/l (January).

The temperature of water of the well ranges from 18.2^0c (January) to 24.5^0c (September). The turbidity of the water ranges from 2.4NTU (October) to 4.2 NTU (August) and p^H ranges from 7.6 (November, February, June) to 8.2 (September). While D.O. ranges from 4.6 mg/.l (February) to 6.2 mg/l (December), free CO_2 ranges from 3.6 mg/l (February) to 4.2 mg/l (April & May), B.O.D. ranges from 1.5 mg/l (October, November and July) to 2.8 mg/l (Mach), total hardness ranges from 510mg/l (March) to 770 mg/l (January), calcium ranges from 240mg/l (February and August) to 405 mg/l (July), magnesium ranges from 40.0 mg/l (March) to 114.2mg/l (August) and faecal coliform ranges from 20.7 mg/l (July) to 24.2mg/l (November). Table (4.2.3.a).It is graphically represented in the Fig 4.2.3.a.

Table 4.2.3.a: Analysis Physico –chemical and biological parameters of the water of well, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	22.5	22.5	19.3	18.2	20.6	21.3	22.3	23.5	23.4	23.8	24.2	24.5
Turbidity (NTU)	2.4	2.8	3.1	2.9	3.1	3.3	4.1	3.7	8.1	8.0	4.2	2.8
pH	7.8	7.6	8.1	8.0	7.6	7.9	7.8	7.9	7.6	7.6	8.1	8.2
D.O.(mg/l)	4.7	5.9	6.2	4.8	4.6	4.9	6.1	5.3	7.6	5.8	5.6	4.8
Free CO_2 (mg/l)	3.9	3.7	4.0	4.1	3.6	3.7	4.2	4.2	4.0	4.1	4.1	5.9
B.O.D. (mg/l)	1.5	1.5	2.1	1.6	1.8	2.8	1.8	2.1	3.1	1.5	2.4	2.6
Total Hardness (mg/l)	59.0	66.0	45.0	77.0	64.0	51.0	63.0	54.0	63.0	68.0	71.0	70.3
Calcium (mg/l)	29.0	34.0	39.0	33.5	24.0	34.5	26.5	32.5	36.5	40.5	24.0	40.0
Magnesium (mg/l)	7.2	7.7	7.4	10.5	9.7	4.0	8.8	5.2	6.4	6.6	11.4	7.2
Faecal Coliform (mg/l)	23.8	24.2	23.6	24.0	21.2	21.0	22.7	22.7	21.8	20.7	20.8	22.5

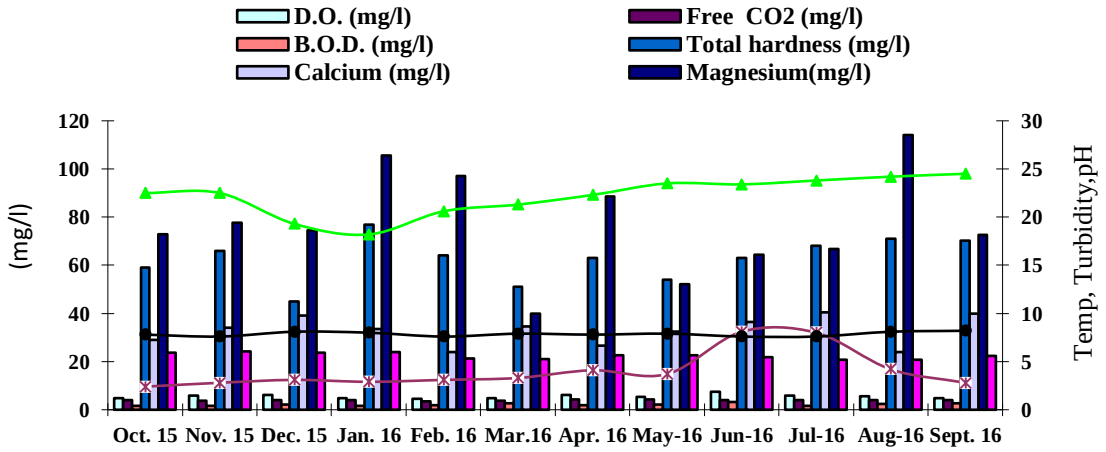

Fig. 4.2.3.a: Analysis Physico-chemical and biological parameters of the water of well water, Chandel District (October 2015 to September 2016)

Table 4.2.3.a highlighted the various physic-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The temperature of water of the well ranges from 18.2^0c (January) to 24.5^0c (September). The turbidity of the water ranges from 2.4NTU (October) to 4.2 NTU (August) and p^H ranges from 7.6 (November, February, June) to 8.2 (September). While D.O. ranges from 4.6 mg/.l (February) to 6.2 mg/l (December), free CO_2 ranges from 3.6 mg/l (February) to 4.2 mg/l (April & May), B.O.D. ranges from 1.5 mg/l (October, November and July) to 2.8 mg/l (Mach), total hardness ranges from 510mg/l (March) to 770 mg/l (January), calcium ranges from 240mg/l (February and August) to 405 mg/l (July), magnesium ranges from 40.0 mg/l (March) to 114.2mg/l (August) and faecal coliform ranges from 20.7 mg/l (July) to 24.2mg/l (November).

The temperature of water of the well ranges from 18.0°c (January) to 24.4°c (September). The turbidity of the water ranges from 2.3 NTU (October) to 8.2 NTU (June) and pH ranges from 7.5 (November, February, June) to 8.3 (September). While D.O. ranges from 4.8 mg/.l (February) to 7.4 mg/l (July), free CO_2 ranges from 3.5 mg/1 (March) to 4.3 mg/1 (March), B.O.D. ranges from 1.4 mg/1 (November) to 3.3 mg/l (June), total hardness ranges from 45.2mg/1 (December) to 76.8 mg/l (January), calcium ranges from 24.2mg/1 (February and August) to 40.6 mg/l (July), magnesium ranges from 1.4 mg/1 (August) to 10.4 mg/l (January) and faecal coliform ranges from 20.1 mg/l (September) to 26.1mg/I (November). Table (4.2.3.b). It is graphically represented in Fig. 4.2.3.b.

Table 4.2.3.b: Physico –chemical and biological parameters of the water of well, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	22.6	22.4	19.5	18.0	20.4	21.1	22.4	23.4	23.2	23.6	24.0	24.4
Turbidity (NTU)	2.3	2.8	3.0	2.7	3.3	3.0	4.3	3.8	8.2	8.1	4.3	2.8
pH	7.9	7.7	8.1	8.2	7.5	7.7	7.6	8.0	7.7	7.6	8.2	8.3
D.O.(mg/l)	4.9	5.6	6.4	4.9	4.8	4.9	4.9	6.3	5.5	7.4	5.5	5.8
Free CO_2 (mg/l)	3.7	3.9	4.2	4.2	3.7	3.5	4.0	4.3	4.2	4.1	4.1	3.7
B.O.D. (mg/l)	1.6	1.4	2.0	1.5	1.9	2.6	1.6	2.4	3.3	1.6	2.5	2.7
Total Hardness (mg/l)	58.7	66.2	45.2	76.8	63.7	49.7	62.8	54.2	63.4	68.0	71.2	70.4
Calcium (mg/l)	28.8	33.8	38.9	33.7	24.2	34.6	26.4	32.7	36.7	40.6	24.2	40.2
Magnesium (mg/l)	7.2	7.8	1.5	10.4	9.5	3.6	8.8	5.2	6.4	6.6	1.4	7.3
Faecal Coliform (mg/l)	25.8	26.1	24.7	25.2	22.1	22.8	23.6	23.5	23.8	24.8	22.1	20.1

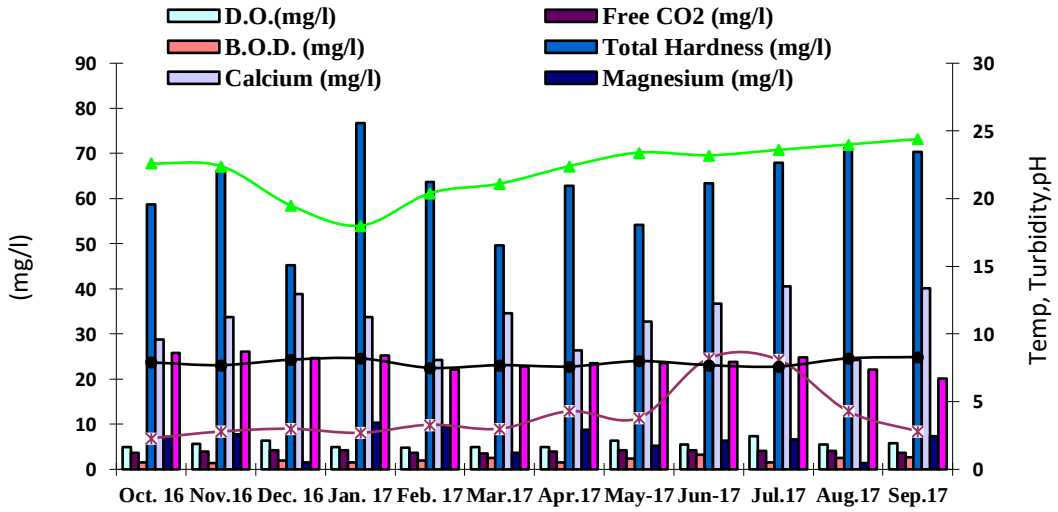

Fig. 4.2.3.b: Physico-chemical and biological parameters of the water of well water, Chandel District (October 2016 to September 2017)

Table 4.2.3.b highlighted the various physic-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The temperature of water of the well ranges from 18.0°c (January) to 24.4°c (September). The turbidity of the water ranges from 2.3 NTU (October) to 8.2 NTU (June) and pH ranges from 7.5 (November, February, June) to 8.3 (September). While D.O. ranges from 4.8 mg/.l (February) to 7.4 mg/l (July), free CO_2 ranges from 3.5 mg/1 (March) to 4.3 mg/1 (March), B.O.D. ranges from 1.4 mg/1 (November) to 3.3 mg/l (June), total hardness ranges from 45.2mg/1 (December) to 76.8 mg/l (January), calcium ranges from 24.2mg/1 (February and August) to 40.6 mg/l (July), magnesium ranges from 1.4 mg/1 (August) to 10.4 mg/l (January) and faecal coliform ranges from 20.1 mg/l (September) to 26.1mg/I (November).

The temperature of water of the well ranges from 18.2°C (January) to 24.5°C (October). The turbidity of the water ranges from 2.4 NTU (October) to 8.5 NTU (August) and pH ranges from 7.5 (February, April, July) to 8.16 (January). While D.O. ranges from 4.7 mg/.l (May) to 6.5 mg/l (January), free CO_2 ranges from 3.6 mg/1 (March) to 4.5 mg/1 (August), B.O.D. ranges from 1.4 mg/1 (October) to 2.9 mg/l (August), total hardness ranges from 45.2mg/1 (December) to 71.4 mg/l (August), calcium ranges from 24.3mg/1 (February) to 40.7 mg/l (July), magnesium ranges from 1.6 mg/1 (December) to 114.2mg/l (August) and faecal coliform ranges from 20.7 mg/l (July) to 24.2mg/I (November). Table (4.2.3.c). It is graphically represented in Fig. 4.2.3.c.

Table 4.2.3.c: Analysis Physico –chemical and biological parameters of the water of well, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	24.7	22.3	19.7	18.2	20.3	22.3	23.1	23.0	23.5	23.8	24.3	24.5
Turbidity (NTU)	2.4	2.6	2.8	2.9	3.4	3.2	4.2	3.9	8.5	8.4	4.6	2.6
pH	8.0	7.8	8.2	8.1	7.5	7.6	7.5	7.6	7.8	7.5	8.4	8.6
D.O.(mg/l)	4.9	5.0	5.7	6.5	4.9	5.0	4.8	4.7	4.8	3.6	5.7	5.9
Free CO_2 (mg/l)	4.0	4.0	4.4	4.4	3.8	3.6	4.2	4.4	4.5	4.3	4.5	3.8
B.O.D. (mg/l)	1.4	1.5	1.9	1.7	1.7	2.8	1.7	2.5	3.4	1.8	2.9	2.8
Total Hardness (mg/l)	58.9	66.4	45.2	76.6	64.0	50.1	62.0	54.0	63.3	68.3	71.4	70.6
Calcium (mg/l)	29.2	34.1	38.6	33.9	24.3	35.0	26.4	32.9	36.8	40.7	24.3	40.3
Magnesium (mg/l)	7.2	7.8	1.6	10.3	8.6	3.6	8.6	5.1	6.4	6.7	11.4	7.3
Faecal Coliform (mg/l)	24.1	25.7	25.2	26.1	23.8	23.1	23.0	22.6	24.5	25.2	22.5	20.6

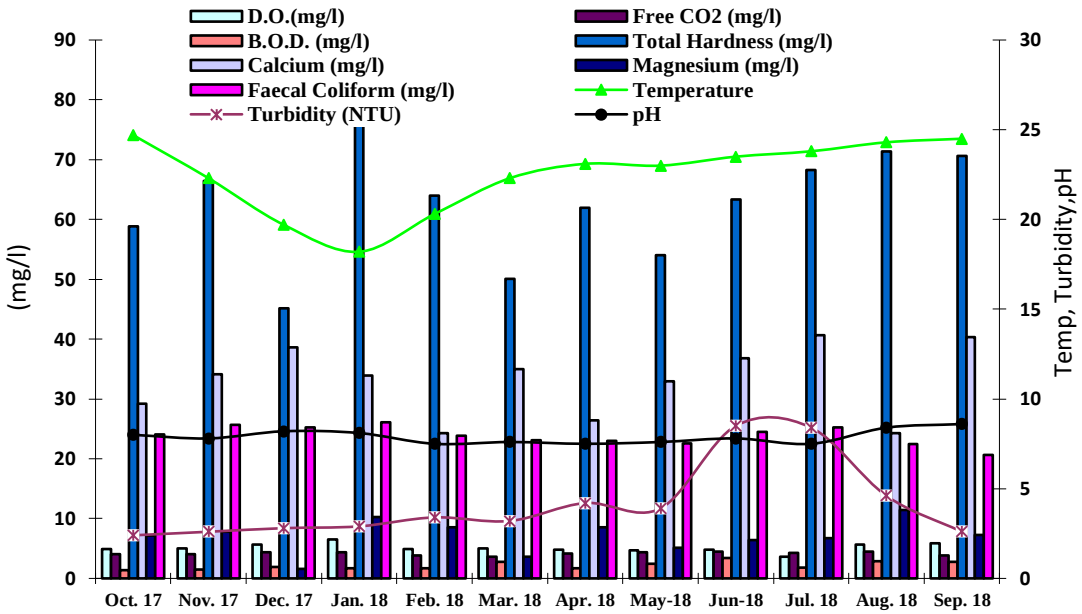

Fig. 4.2.3.c: Analysis Physico-chemical and biological parameters of the water of well water, Chandel District (October 2017 to September 2018)

Table 4.2.3.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The temperature of water of the well ranges from 18.2°C (January) to 24.5°C (October). The turbidity of the water ranges from 2.4 NTU (October) to 8.5 NTU (August) and pH ranges from 7.5 (February, April, July) to 8.16 (January). While D.O. ranges from 4.7 mg/.l (May) to 6.5 mg/l (January), free CO_2 ranges from 3.6 mg/1 (March) to 4.5 mg/1 (August), B.O.D. ranges from 1.4 mg/1 (October) to 2.9 mg/l (August), total hardness ranges from 45.2mg/1 (December) to 71.4 mg/l (August), calcium ranges from 24.3mg/1 (February) to 40.7 mg/l (July), magnesium ranges from 1.6 mg/1 (December) to 114.2mg/l (August) and faecal coliform ranges from 20.7 mg/l (July) to 24.2mg/I (November).

The temperature of handpump water ranges from 19.1^0c (January) to 24.3^0c (July), turbidity from 3.8NTU (November) to 5.8NTU (July), p^H from 7.5 (November) to 8.2 (July), D.O. from 6.4 mg/l (July) to 70 (June), free CO_2 from 4.1mg/l (October) to 7.9 (July), B.O.D. from 3.5mg/l (November and June) to 4.9 mg/l(July), total

hardness 84.4 mg/l (February) to 224.0mg/l (April), Calcium 8.8 mg/l (July) to 31.5mg/l (April), magnesium 17.3mg/l (February) to 46.8mg/l (April) and faecal coliform 41.8mg/l (March) to 68.2mg/l (November) (Table 4.2.4.a). It is graphically represented in the Fig 4.2.4.a.

Table 4.2.4.a: Analysis Physico-chemical and biological parameters of the water of hand pump, Chandel District (October 2015 to September 2016)

Parameters	Oct. 15	Nov. 15	Dec. 15	Jan. 16	Feb. 16	Mar. 16	Apr. 16	May 16	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	23.1	22.4	20.2	19.1	20.1	20.2	23.6	23.2	24.2	24.3	23.1	23.3
Turbidity (NTU)	4.6	3.8	4.7	4.4	3.9	4.2	4.5	4.2	5.6	5.8	4.0	4.8
pH	7.7	7.5	7.9	7.6	7.6	7.7	7.8	7.6	8.1	8.2	7.8	7.7
D.O.(mg/l)	6.7	6.8	7.0	6.5	6.9	6.7	6.8	6.8	7.0	6.4	6.5	6.8
Free CO_2 (mg/l)	4.1	5.2	6.3	5.4	4.8	6.8	5.9	7.3	7.8	7.9	6.5	5.8
B.O.D. (mg/l)	4.8	3.5	4.6	4.7	4.8	3.8	3.6	3.9	3.5	4.9	4.7	4.6
Total Hardness (mg/l)	138.0	144.0	124.0	154.2	84.4	194.2	224.0	136.4	136.5	136.6	136.4	125.5
Calcium (mg/l)	16.0	28.1	15.2	26.5	12.8	31.3	31.3	19.2	26.5	8.8	12.4	14.3
Magnesium (mg/l)	29.6	28.1	26.4	31.0	17.3	39.3	46.8	28.4	26.7	31.0	30.1	27.0
Faecal Coliform (mg/l)	68.0	68.2	51.0	48.9	49.1	41.8	42.7	43.5	43.5	50.2	50.5	50.8

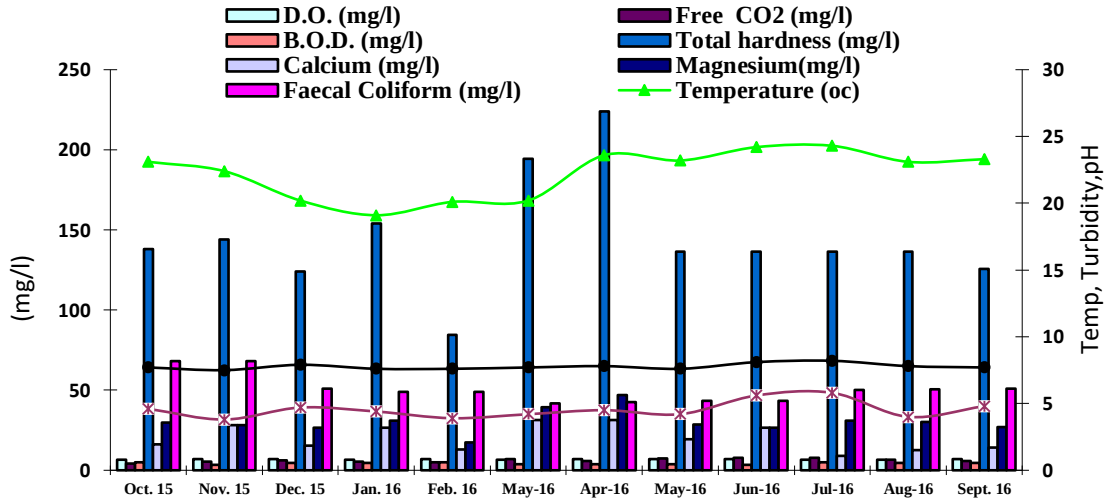

Fig. 4.2.4.a: Physico-chemical and biological parameters of the waters of handpump water, Chandel district (October 2015 to September 2016)

Table 4.2.4.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The temperature of handpump water ranges from 19.1^{0}c (January) to 24.3^{0}c (July), turbidity from 3.8NTU (November) to 5.8NTU (July), p^H from 7.5

(November) to 8.2 (July), D.O. from 6.4 mg/l (July) to 70 (June), free CO_2 from 4.1mg/l (October) to 7.9 (July), B.O.D. from 3.5mg/l (November and June) to 4.9 mg/l(July), total hardness 84.4 mg/l (February) to 224.0mg/l (April), Calcium 8.8 mg/l (July) to 31.5mg/l (April), magnesium 17.3mg/l (February) to 46.8mg/l (April) and faecal coliform 41.8mg/l (March) to 68.2mg/l (November).

The temperature of handpump water ranges from 18.9^{o}C (January) to 24.9°C (July), turbidity from 3.6 NTU (November) to 5.8 NTU (June), pH from 7.5 (May) to 8.4 (July), D.O. from 6.5 mg/l (July) to 8.4 (July), free CO_2 from 4.3 mg/1 (October) to 7.9 (June), B.O.D. from 3.6 mg/l (November) to 5.0 mg/I(October), total hardness 94.0 mg/1 (February) to 221.2mg/l (April), Calcium 8.9 mg/l (July) to 31.8 mg/l (April), magnesium 19.9 mg/l (February) to 46.0 mg/1 (April) and faecal coliform 43.3 mg/1 (May) to 70.2mg/l (November) (Table 4.2.4.b). It is graphically represented in the Fig 4.2.4.b.

Table 4.2.4.b: Analysis Physico-chemical and biological parameters of the water of hand pump, Chandel District (October 2016 to September 2017)

Parameters	**Oct. 16**	**Nov. 16**	**Dec. 16**	**Jan. 17**	**Feb. 17**	**Mar. 17**	**Apr. 17**	**May 17**	**June 17**	**Jul. 17**	**Aug. 17**	**Sep. 17**
Temperature	23.6	22.1	19.8	18.9	19.1	20.3	22.8	23.8	24.6	24.9	23.3	23.5
Turbidity (NTU)	4.8	3.6	4.9	4.8	4.1	4.0	4.7	4.4	5.8	6.0	4.4	4.9
pH	7.9	7.6	7.8	7.6	7.8	7.9	7.7	7.5	8.2	8.4	7.6	7.7
D.O.(mg/l)	6.8	6.6	6.9	6.6	7.0	6.8	6.8	6.9	7.1	6.5	6.6	6.8
Free CO_2 (mg/l)	4.3	5.0	6.1	5.1	4.8	6.8	5.6	7.5	7.9	6.2	6.4	5.5
B.O.D. (mg/l)	5.0	3.6	4.4	4.9	4.9	4.0	3.8	4.1	3.8	4.6	4.5	4.4
Total Hardness (mg/l)	136.5	145.2	121.9	150.1	94.0	184.0	221.2	145.5	133.0	130.5	138.2	126.5
Calcium (mg/l)	16.2	28.4	15.3	24.5	12.1	30.8	31.8	18.8	27.2	8.9	12.6	15.1
Magnesium (mg/l)	29.2	28.3	25.9	30.5	19.9	37.2	46.0	30.7	25.7	29.5	30.5	23.9
Faecal Coliform (mg/l)	68.1	70.2	54.2	49.8	48.9	48.1	47.2	43.3	50.2	50.4	50.0	50.9

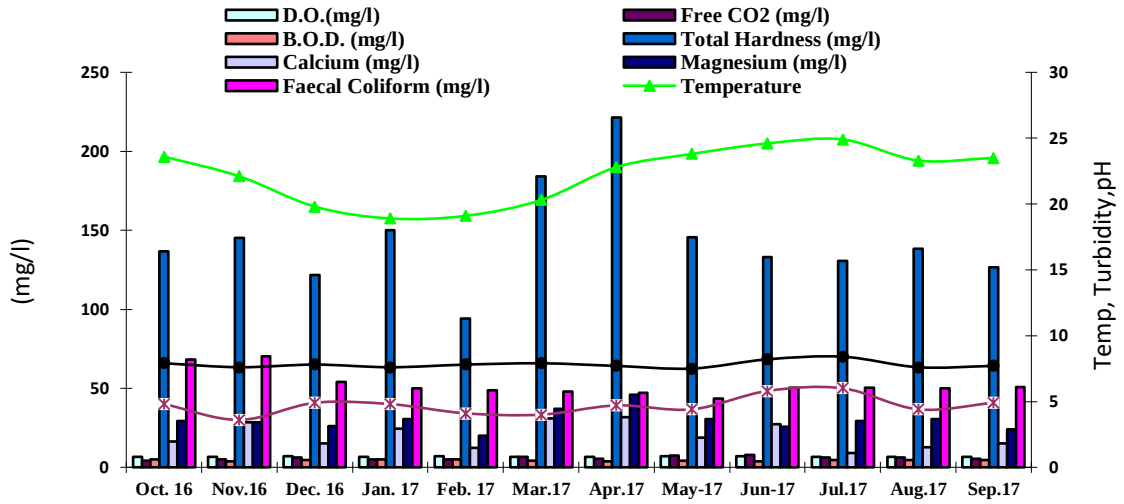

Table 4.2.4.b: Physico –chemical and biological parameters of the water of hand pump, Chandel District (October 2016 to September 2017)

Table 4.2.4.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The temperature of handpump water ranges from 18.9^{o}C (January) to 24.9°C (July), turbidity from 3.6 NTU (November) to 5.8 NTU (June), pH from 7.5 (May) to 8.4 (July), D.O. from 6.5 mg/l (July) to 8.4 (July), free CO_2 from 4.3 mg/1 (October) to 7.9 (June), B.O.D. from 3.6 mg/l (November) to 5.0 mg/I(October), total hardness 94.0 mg/1 (February) to 221.2mg/l (April), Calcium 8.9 mg/l (July) to 31.8 mg/l (April), magnesium 19.9 mg/l (February) to 46.0 mg/1 (April) and faecal coliform 43.3 mg/1 (May) to 70.2mg/l (November).

The temperature of handpump water ranges from 19.1^{o}C (January) to 24.8°C (June), turbidity from 3.5 NTU (November) to 6.3 NTU (July), pH from 7.2 (May) to 8.6 (July), D.O. from 6.6 mg/l (July) to 7.2 (June), free CO_2 from 4.5 mg/1 (October) to 7.4 (June), B.O.D. from 3.1 mg/l (April) to 5.1 mg/I(October), total hardness 95.8 mg/1 (February) to 220.0 mg/l (April), Calcium 8.6 mg/l (July) to 34.1 mg/l (January), magnesium 19.4 mg/l (February) to 36.9 mg/1 (March) and faecal coliform 44.2 mg/1 (May) to 68.2mg/l (November) (Table 4.2.4.c). It is graphically represented in the Fig 4.2.4.c.

Table 4.2.4.c: Analysis Physico –chemical and biological parameters of the water of hand pump, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	July 18	Aug. 18	Sep. 18
Temperature	23.7	22.3	19.6	19.1	19.4	20.0	23.0	23.9	24.8	24.7	23.5	23.8
Turbidity (NTU)	5.0	3.5	4.6	4.6	4.2	4.3	4.6	5.0	5.4	6.3	4.6	4.7
pH	7.6	7.8	7.9	7.7	7.5	7.6	7.5	7.2	8.4	8.6	7.7	7.9
D.O.(mg/l)	6.9	6.7	7.0	6.7	7.1	6.9	6.7	6.8	7.2	6.6	6.8	6.9
Free CO_2 (mg/l)	4.5	5.1	6.2	5.2	4.9	6.9	5.8	7.0	7.4	6.5	6.6	5.7
B.O.D. (mg/l)	5.1	3.4	4.0	4.6	4.9	4.5	3.1	4.2	4.7	4.6	4.7	4.8
Total Hardness (mg/l)	140.2	144.4	123.8	151.1	95.8	182.0	220.0	146.0	137.2	130.7	138.6	126.7
Calcium (mg/l)	16.0	26.1	18.1	34.1	13.9	29.8	17.0	28.1	8.9	8.6	12.8	15.4
Magnesium (mg/l)	30.1	28.7	25.6	30.8	19.9	36.9	49.3	28.6	31.3	29.6	30.5	27.0
Faecal Coliform (mg/l)	60.9	68.2	54.2	48.8	47.1	46.4	46.2	44.2	51.1	50.8	50.4	51.2

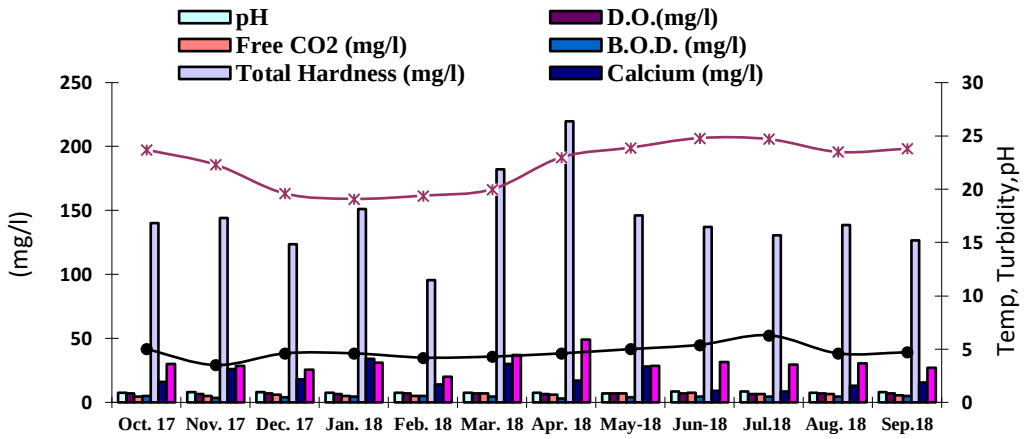

Table 4.2.4.c: Analysis Physico –chemical and biological parameters of the water of hand pump, Chandel District (October 2016 to September 2017)

Table 4.2.4.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The temperature of handpump water ranges from 19.1^{O}C (January) to 24.8°C (June), turbidity from 3.5 NTU (November) to 6.3 NTU (July), pH from 7.2 (May) to 8.6 (July), D.O. from 6.6 mg/l (July) to 7.2 (June), free CO_2 from 4.5 mg/1 (October) to 7.4 (June), B.O.D. from 3.1 mg/l (April) to 5.1 mg/I(October), total hardness 95.8 mg/1 (February) to 220.0 mg/l (April), Calcium 8.6 mg/l (July) to 34.1 mg/l (January), magnesium 19.4 mg/l (February) to 36.9 mg/1 (March) and faecal coliform 44.2 mg/1 (May) to 68.2mg/l (November).

The water temperature of the tube well of Chandel district recorded 20.0^{0}C (December) as minimum and 24.4°C (July) as maximum. The turbidity ranged between 3.6 NTU (November) to 5.7 NTU (June) and pH ranged 6.4(August) to 7.8 (October). The D.O. was observed 6.4mg/l (minimum) in January and 7.2mg/1 (maximum) in June. The B.O.D. was higher 4.9mg/1 in August and lower 3.6mg/l in November. The maximum total hardness was observed March (19.2mg/1) and minimum in October (12.0mg/1). The concentration of calcium ranged between 13.5mg/l (August) to 32.4mg/l (April). The magnesium concentration was observed 0.7mg/l as minimum in December and 3.8mg/l as maximum in November. The total faecal coliform was ranged between 39mg/l (February) to 86mg/l (October). The data were displayed in Table 4.2.5a and fig was displayed in 4.2.5a.

Table 4.2.5.a: Analysis Physico –chemical and biological parameters of the water of Tube well water, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	23.0	22.5	20.0	19.2	20.2	20.1	23.5	23.1	24.3	24.4	23.0	23.2
Turbidity (NTU)	4.8	3.6	4.6	4.7	3.8	4.1	4.6	4.3	5.5	5.7	4.2	4.7
pH	7.8	7.4	6.9	6.6	7.0	6.6	6.9	6.7	7.2	6.6	6.4	6.7
D.O.(mg/l)	6.6	6.9	7.1	6.4	6.8	6.8	6.7	6.9	7.2	6.5	6.7	6.9
Free CO_2 (mg/l)	4.3	5.4	6.5	5.6	4.6	6.6	5.7	7.0	7.6	7.7	6.3	5.7
B.O.D. (mg/l)	4.6	3.6	4.5	4.6	4.6	3.9	3.8	4.2	3.7	4.8	4.9	4.5
Total Hardness (mg/l)	12.0	13.4	13.0	14.4	9.4	19.2	21.2	14.6	15.6	14.5	13.8	12.5
Calcium (mg/l)	17.0	29.1	16.2	27.4	13.7	32.2	32.4	19.9	27.5	18.7	13.5	15.3
Magnesium (mg/l)	1.2	3.8	0.7	3.1	1.0	3.1	2.7	1.2	2.8	1.0	1.2	0.6
Faecal Coliform (mg/l)	86	78	61	58	39	51	43	53	48	52	50	52

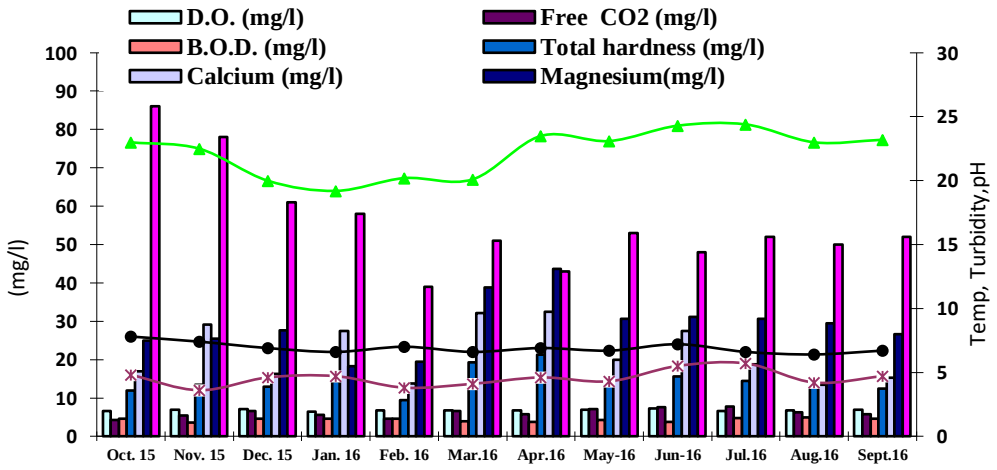

Fig.4.2.5.a: Analysis Physico-chemical and biological parameters of the water of tube well, Chandel district (October 2015 to September 2016)

Table 4.2.5.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The water temperature of the tube well of Chandel district recorded 20.0^0C (December) as minimum and 24.4°C (July) as maximum. The turbidity ranged between 3.6 NTU (November) to 5.7 NTU (June) and pH ranged 6.4(August) to 7.8 (October). The D.O. was observed 6.4mg/l (minimum) in January and 7.2mg/1 (maximum) in June. The B.O.D. was higher 4.9mg/1 in August and lower 3.6mg/l in November. The maximum total hardness was observed March (19.2mg/1) and minimum in October (12.0mg/1). The concentration of calcium ranged between 13.5mg/l (August) to 32.4mg/l (April). The magnesium concentration was observed 0.7mg/l as minimum in December and 3.8mg/l as maximum in November. The total faecal coliform was ranged between 39mg/l (February) to 86mg/l (October).

The water temperature of the tube well of Chandel district recorded 19.4^0C (January) as minimum and 24.6°C (July) as maximum. The turbidity ranged between 3.5 NTU (November) to 5.8 NTU (June) and pH ranged 6.5(August) to 7.6 (October). The D.O. was observed 6.5mg/l (minimum) in March and August and 7.4mg/1 (maximum) in June. The free CO_2 ranged between 4.0mg/l (October) to 7.7mg/l (June). The B.O.D. was higher 4.8mg/1 in February and August and lower 3.5mg/l in April. The maximum total hardness was observed March (19.4mg/1) and minimum in October (12.2mg/1). The concentration of calcium ranged between 13.0mg/l (August) to 32.5mg/l (April). The magnesium concentration was observed 0.1mg/l as minimum in August and 3.8mg/l as maximum in November. The total faecal coliform was ranged between 34.0mg/l (July) to 86mg/l (October). The data were displayed in Table 4.2.5.b and fig was displayed in 4.2.5.b.

Table 4.2.5.b: Analysis Physico –chemical and biological parameters of the water of Tube well water, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	23.2	22.7	20.4	19.4	20.0	20.3	23.2	22.8	24.1	24.6	22.7	22.8
Turbidity (NTU)	4.9	3.5	4.8	4.9	3.9	4.2	4.9	4.5	5.6	5.8	4.4	4.4
pH	7.6	7.6	7.1	6.8	7.1	6.8	7.1	6.9	7.0	6.7	6.5	6.9
D.O.(mg/l)	6.8	7.2	7.3	6.7	6.9	6.5	6.9	7.0	7.4	6.8	6.5	6.6
Free CO_2 (mg/l)	4.0	5.6	6.6	6.5	6.4	6.2	5.2	6.9	7.7	7.6	6.1	5.5
B.O.D. (mg/l)	4.7	3.8	4.2	4.7	4.8	3.7	3.5	4.0	3.9	4.7	4.8	4.4
Total Hardness (mg/l)	12.2	13.1	13.3	14.2	9.1	19.4	21.0	14.5	15.4	14.6	13.7	12.6
Calcium (mg/l)	17.1	28.8	16.4	27.5	13.9	31.9	32.5	20.2	26.9	19.0	13.0	15.5
Magnesium (mg/l)	1.1	3.8	0.7	3.2	1.1	3.0	2.7	1.3	2.7	1.0	0.1	0.7
Faecal Coliform (mg/l)	77	86	59	61	49	48	52	64	56	34	58	50

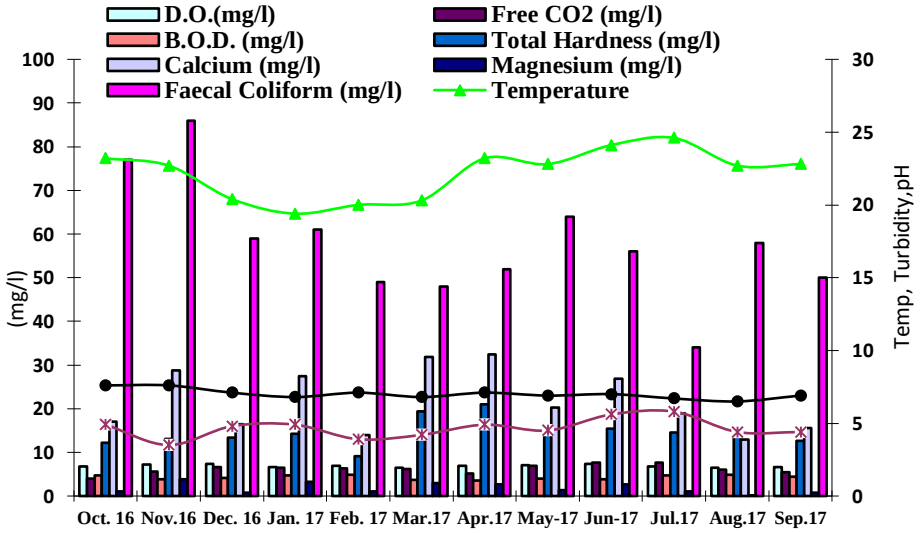

Fig.4.2.5.b: Analysis Physico-chemical and biological parameters of the water of tube well, Chandel district (October 2016 to September 2017)

Table 4.2.5.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of the tube well of Chandel district recorded 19.4^{0}C (January) as minimum and 24.6°C (July) as maximum. The turbidity ranged between 3.5 NTU (November) to 5.8 NTU (June) and pH ranged 6.5(August) to 7.6 (October). The D.O. was observed 6.5mg/l (minimum) in March and August and 7.4mg/1 (maximum) in June. The free CO_2 ranged between 4.0mg/l (October) to 7.7mg/l (June). The B.O.D. was higher 4.8mg/1 in February and August and lower

3.5mg/l in April. The maximum total hardness was observed March (19.4mg/1) and minimum in October (12.2mg/1). The concentration of calcium ranged between 13.0mg/l (August) to 32.5mg/l (April). The magnesium concentration was observed 0.1mg/l as minimum in August and 3.8mg/l as maximum in November. The total faecal coliform was ranged between 34.0mg/l (July) to 86mg/l (October).

The water temperature of the tube well of Chandel district recorded 19.6^{0}C (January) as minimum and 24.5°C (June) as maximum. The turbidity ranged between 3.7 NTU (November) to 5.8 NTU (June) and pH ranged 6.6(August) to 7.9 (October). The D.O. was observed 6.0mg/l (minimum) in August and 7.4mg/1 (maximum) in May. The free CO_2 recorded 4.8 mg/l (October) a minimum and 7.6mg/l (June) as maximum. The B.O.D. was higher 4.8mg/1 in October and lower 3.2mg/l in April. The maximum total hardness was observed in March (20.8mg/1) and minimum in February (10.0mg/1). The concentration of calcium ranged between 13.6mg/l (August) to 30.6mg/l (April). The magnesium concentration was observed 0.07mg/l as minimum in August and 2.6mg/l as maximum in March. The total faecal coliform was ranged between 40mg/l (July) to 81mg/l (October). The free CO_2 recorded 4.8mg/l (October) as minimum and 7.6mg/l (June) as maximum. The data were displayed in Table 4.2.5c and fig was displayed in 4.2.5c.

Table 4.2.5.c: Analysis Physico –chemical and biological parameters of the water of Tube well water, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov.17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	23.4	22.9	20.5	19.6	19.8	20.0	23.1	22.4	24.5	24.2	23.0	23.1
Turbidity (NTU)	5.2	3.7	4.6	4.9	4.2	4.2	4.3	5.0	5.8	5.6	4.2	4.1
pH	7.9	7.7	7.2	6.6	7.0	6.9	7.2	7.0	6.7	7.2	7.0	7.2
D.O.(mg/l)	6.7	7.0	7.1	6.8	7.0	6.7	7.2	7.4	7.2	7.0	6.0	7.0
Free CO_2 (mg/l)	4.8	5.5	6.5	6.7	6.2	6.3	5.5	7.0	7.6	7.5	5.9	5.8
B.O.D. (mg/l)	4.8	3.9	4.1	4.6	4.3	3.9	3.2	3.9	4.1	4.5	4.5	4.7
Total Hardness (mg/l)	11.9	13.3	13.1	14.0	10.0	19.0	20.8	14.6	15.5	14.4	13.9	12.5
Calcium (mg/l)	17.3	28.9	15.9	26.0	14.0	29.9	30.6	22.9	24.5	19.1	13.6	15.8
Magnesium (mg/l)	1.3	3.7	0.6	2.9	0.9	2.6	2.3	2.0	2.1	1.1	0.07	0.8
Faecal Coliform (mg/l)	81	74	54	60	43	66	67	67	51	40	49	42

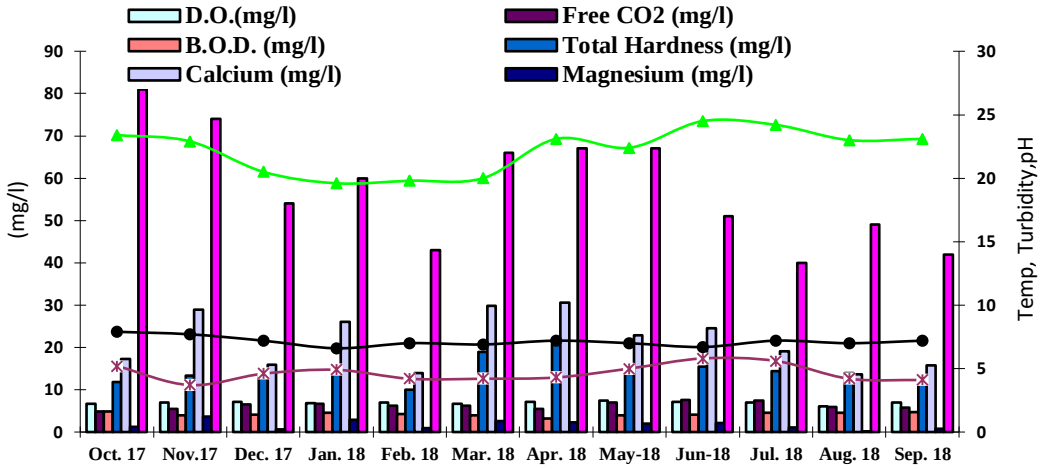

Fig.4.2.5.c: Analysis Physico-chemical and biological parameters of the water of tube well, Chandel district (October 2017 to September 2018)

Table 4.2.5.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The water temperature of the tube well of Chandel district recorded 19.6^{0}C (January) as minimum and 24.5°C (June) as maximum. The turbidity ranged between 3.7 NTU (November) to 5.8 NTU (June) and pH ranged 6.6(August) to 7.9 (October). The D.O. was observed 6.0mg/l (minimum) in August and 7.4mg/1 (maximum) in May. The free CO_2 recorded 4.8 mg/l (October) a minimum and 7.6mg/l (June) as maximum. The B.O.D. was higher 4.8mg/1 in October and lower 3.2mg/l in April. The maximum total hardness was observed in March (20.8mg/1) and minimum in February (10.0mg/1). The concentration of calcium ranged between 13.6mg/l (August) to 30.6mg/l (April). The magnesium concentration was observed 0.07mg/l as minimum in August and 2.6mg/l as maximum in March. The total faecal coliform was ranged between 40mg/l (July) to 81mg/l (October). The free CO_2 recorded 4.8mg/l (October) as minimum and 7.6mg/l (June) as maximum.

The temperature of the water of spring ranges from 19.8°c (February) to 24.5°c (October), turbidity from 7.4 NTU (September) to 10.1 NTU (March), pH from 5.7 (July) to 6.3 (September), D.O. from 4.0 (November and August) to 5.2 mg/l (March), free CO_2 from 5.7 mg/1 (September) to 7.8 mg/I(March), B.O.D. from 5.5 mg/l (September) to 6.5 mg/l (November), total hardness from 16.05 mg/l (July) to 19.2 mg/l

(March), Calcium from 11.1 mg/l (March) to 12.4 mg/l (May), magnesium from 0.8 mg/l (May) to 1.9 mg/1 (March) and faecal coliform from 24mg/1 (February) to 42mg/1 (November) (Table 4.2.6.a). The values of different parameters were displayed in Fig 4.2.6.a.

Table 4.2.6.a: Analysis Physico –chemical and biological parameters of the water of Spring, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	24.5	23.2	22.1	20.9	19.8	20.7	22.8	23.4	23.8	24.3	24.2	23.0
Turbidity (NTU)	10.2	8.1	9.3	7.9	8.4	10.1	9.4	7.5	7.7	8.2	7.8	7.4
pH	6.0	5.8	6.2	6.1	5.9	6.0	6.1	5.9	5.8	5.7	5.9	6.3
D.O.(mg/l)	4.2	4.0	4.3	5.1	4.1	5.2	5.1	4.0	4.2	4.4	4.0	4.1
Free CO_2 (mg/l)	7.2	7.0	6.3	6.0	5.8	7.8	7.5	7.2	6.8	6.9	5.8	5.7
B.O.D. (mg/l)	6.2	6.5	6.1	6.0	6.0	5.9	5.8	5.7	6.0	6.0	5.6	5.5
Total Hardness (mg/l)	19.1	18.6	18.7	19.0	18.9	19.2	17.5	16.2	16.1	16.0	17.4	17.3
Calcium (mg/l)	12.2	11.8	11.6	12.0	11.1	11.3	12.3	12.4	12.3	11.8	11.9	11.6
Magnesium (mg/l)	1.6	1.6	1.7	1.7	1.8	1.9	1.2	0.8	0.9	1.0	1.3	1.3
Faecal Coliform (mg/l)	38	42	36	40	24	31	27	29	28	27	28	25

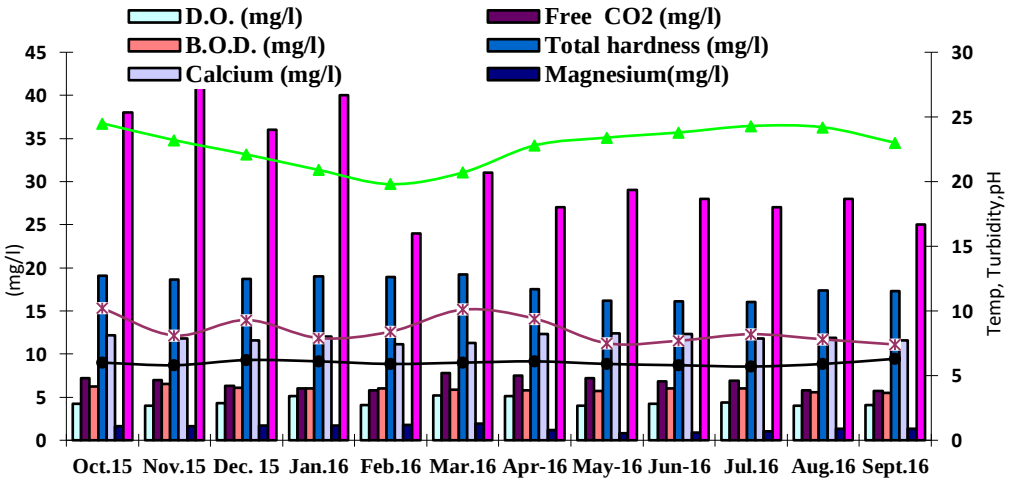

Fig. 4.2.6.a: Analysis Physico-chemical and biological parameters of the water of spring, Chandel district (October 2015 to September 2016)

Table 4.2.6.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The temperature of the water of spring ranges from 19.8°c (February) to 24.5°c (October), turbidity from 7.4 NTU (September) to 10.1 NTU (March), pH from 5.7 (July) to 6.3 (September), D.O. from 4.0 (November and August) to 5.2 mg/l (March), free CO_2 from 5.7 mg/1 (September) to 7.8 mg/I(March), B.O.D. from 5.5 mg/l (September) to 6.5 mg/l (November), total hardness from 16.05 mg/l (July) to 19.2

mg/l (March), Calcium from 11.1 mg/l (March) to 12.4 mg/l (May), magnesium from 0.8 mg/l (May) to 1.9 mg/1 (March) and faecal coliform from 24mg/1 (February) to 42mg/1 (November).

The temperature of the water of spring ranges from 20.0°c (February) to 24.0°c (October and July), turbidity from 6.9 NTU (May) to 10.5 NTU (October), p^H from 5.2 (November) to 6.6 (September), D.O. from 4.3 (December) to 5.9 mg/l (August), free CO_2 from 5.6 mg/1 (February) to 7.8 mg/l (October), B.O.D. from 5.7 mg/l (August) to 6.8 mg/l (December), total hardness from 15.8 mg/l (June) to 20.2 mg/l (October), Calcium from 10.2 mg/l (August) to 12.6 mg/l (May), magnesium from 0.9 mg/l (May and June) to 1.9 mg/1 (October) and faecal coliform from 25.0mg/1 (July) to 44.0mg/1 (November) (Table 4.2.6.b). The values of different parameters were displayed in Fig 4.2.6.b.

Table 4.2.6.b: Analysis Physico –chemical and biological parameters of the water of Spring, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	24.0	23.5	22.4	20.7	20.0	20.2	22.5	23.0	23.4	24.0	23.9	23.4
Turbidity (NTU)	10.5	8.4	9.0	8.0	8.5	10.3	9.6	6.9	7.9	8.0	8.1	7.6
pH	5.8	5.2	6.5	5.6	6.1	6.5	5.9	5.4	5.9	5.5	4.8	6.6
D.O.(mg/l)	4.6	4.4	5.3	5.8	4.4	5.0	5.6	4.8	4.5	4.8	5.9	4.9
Free CO_2 (mg/l)	7.8	7.6	6.4	6.4	5.6	7.2	7.0	7.6	6.2	6.6	5.6	6.0
B.O.D. (mg/l)	6.4	6.2	6.8	6.7	5.8	6.2	6.2	5.8	5.8	6.4	5.7	5.9
Total Hardness (mg/l)	20.2	18.8	18.9	19.4	18.4	18.8	16.8	16.4	15.8	15.8	16.8	18.0
Calcium (mg/l)	12.0	11.6	11.8	12.2	11.5	11.1	12.0	12.6	12.0	11.2	10.2	12.4
Magnesium (mg/l)	1.9	1.7	1.7	1.7	1.6	1.8	1.1	0.9	0.9	1.1	1.6	1.3
Faecal Coliform (mg/l)	42.0	44.0	38.0	36.0	28.0	29.0	31.0	26.0	28.0	25.0	30.0	28.0

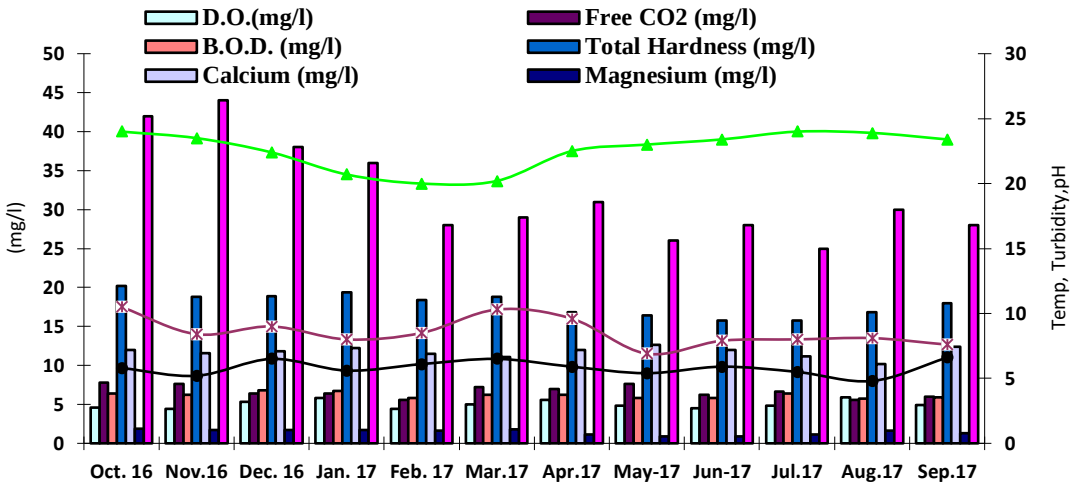

Fig. 4.2.6b: Analysis Physico-chemical and biological parameters of the water of spring, Chandel district (October 2016 to September 2017)

Table 4.2.6.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The temperature of the water of spring ranges from 20.0°c (February) to 24.0°c (October and July), turbidity from 6.9 NTU (May) to 10.5 NTU (October), p^H from 5.2 (November) to 6.6 (September), D.O. from 4.3 (December) to 5.9 mg/l (August), free CO_2 from 5.6 mg/1 (February) to 7.8 mg/l (October), B.O.D. from 5.7 mg/l (August) to 6.8 mg/l (December), total hardness from 15.8 mg/l (June) to 20.2 mg/l (October), Calcium from 10.2 mg/l (August) to 12.6 mg/l (May), magnesium from 0.9 mg/l (May and June) to 1.9 mg/1 (October) and faecal coliform from 25.0mg/1 (July) to 44.0mg/1 (November).

The temperature of the water of spring ranges from 19.7°c (January and March) to 24.4°c (July), turbidity from 6.6 NTU (May) to 10.4 NTU (October), p^H from 4.6 (August) to 6.4 (December), D.O. from 4.2 (December) to 6.5 mg/l (March), free CO_2 from 5.3 mg/1 (March) to 7.8 mg/I(November and May), B.O.D. from 5.2 mg/l (May) to 7.4 mg/l (March), total hardness from 15.4 mg/l (July) to 19.3 mg/l (January), Calcium from 10.4 mg/l (August) to 12.4 mg/l (June, Sept. & Oct.), magnesium from 0.8 mg/l (June) to 1.8 mg/1 (Nov.) and faecal coliform from 23mg/1 (July) to 46mg/1 (November) (Table 4.2.6c). The values of different parameters were displayed in Fig 4.2.6c.

Table 4.2.6.c. Analysis Physico –chemical and biological parameters of the water of Spring, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	24.3	23.0	22.0	19.7	19.9	19.7	23.0	22.9	24.0	24.4	24.0	23.8
Turbidity (NTU)	10.4	9.2	9.2	8.2	8.7	10.2	9.5	6.6	8.2	8.4	8.2	8.4
pH	5.7	5.4	6.4	5.5	6.3	6.2	5.4	5.4	5.8	5.7	4.6	6.2
D.O.(mg/l)	4.6	4.6	4.2	5.4	4.6	6.5	5.5	4.6	4.7	4.8	5.7	5.2
Free CO_2 (mg/l)	7.7	7.8	6.0	6.3	5.4	5.3	6.8	7.8	6.4	6.4	5.8	6.2
B.O.D. (mg/l)	6.8	6.5	6.5	6.8	5.6	7.4	6.4	5.2	5.9	6.7	5.4	6.0
Total Hardness (mg/l)	19.2	18.9	18.6	19.3	18.8	18.2	17.0	16.9	15.8	15.4	15.6	18.2
Calcium (mg/l)	12.4	11.4	11.2	12.0	11.8	11.0	12.3	12.2	12.4	11.4	10.4	12.4
Magnesium (mg/l)	1.6	1.8	1.7	1.7	1.5	1.7	1.1	1.1	0.8	0.9	1.2	1.4
Faecal Coliform (mg/l)	43	46.0	36.0	34.0	30.0	28.0	33.0	28.0	29.0	23.0	28.0	26.0

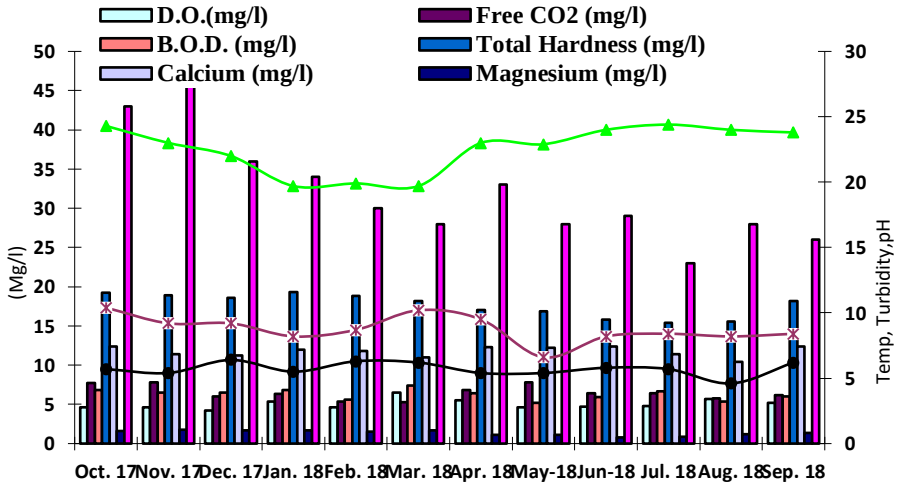

Fig. 4.2.6.c: Analysis Physico-chemical and biological parameters of the water of spring, Chandel district (October 2017 to September 2018)

Table 4.2.6.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The temperature of the water of spring ranges from 19.7°c (January and March) to 24.4°c (July), turbidity from 6.6 NTU (May) to 10.4 NTU (October), p^H from 4.6 (August) to 6.4 (December), D.O. from 4.2 (December) to 6.5 mg/l (March), free CO_2 from 5.3 mg/1 (March) to 7.8 mg/I(November and May), B.O.D. from 5.2 mg/l (May) to 7.4 mg/l (March), total hardness from 15.4 mg/l (July) to 19.3 mg/l (January), Calcium from 10.4 mg/l (August) to 12.4 mg/l (June, Sept. & Oct.), magnesium from 0.8 mg/l (June) to 1.8 mg/1 (Nov.) and faecal coliform from 23mg/1 (July) to 46mg/1 (November).

The water temperature of Maha River was recorded with a range of 22.6^0c (November) to 24.9^0c (September), turbidity with a range of 18.5NTU (January) to 95.5 NTU (September), p^H with a range of 6.8 (October) to 8.5 (September), dissolved oxygen with a range of 4.3 mg/l (September) to 6.4mg/l (July), free carbon dioxide with a range of 8.3 mg/l (September) to 17.2 mg/l (June), B.O.D. with a range of 2.0mg/l (August) to 6.9mg/l (October), total hardness 37.4mg/l (August) to 100.3 mg/l (June), calcium with a range of 7.9 mg/l (September) to 21.8mg/l (May), magnesium with a range of 7.0 mg/l (August) to 19.3mg/l (June), faecal coliform with a range of 131 mg/l (September) to 162mg/l (July). (Table 4.2.7.a). It is graphically displayed in Fig. 4.2.7.a.

Table 4.2.7.a: Analysis Physico –chemical and biological parameters of the water of Maha River, Chandel District (October 2015 to September 2016)

Parameters	**Oct. 15**	**Nov. 15**	**Dec. 15**	**Jan. 16**	**Feb. 16**	**Mar. 16**	**Apr. 16**	**May 16**	**June 16**	**Jul. 16**	**Aug. 16**	**Sep. 16**
Temperature	24.4	22.6	20.4	19.4	20.7	22.8	23.8	24.4	25.4	25.4	24.7	24.9
Turbidity (NTU)	52.8	21.2	208	18.5	23.7	27.8	37.2	55.3	79.6	54.7	91.6	95.5
pH	6.8	7.5	7.3	7.2	7.4	7.5	7.5	7.6	7.8	7.6	7.7	8.5
D.O.(mg/l)	4.6	5.1	5.2	5.1	5.0	5.4	5.6	5.3	5.2	6.8	4.7	4.3
Free CO_2 (mg/l)	10.1	12.6	10.2	10.3	10.6	12.8	12.5	15.8	17.2	15.7	8.4	8.3
B.O.D. (mg/l)	6.9	4.8	5.1	4.1	4.5	4.8	5.8	5.9	5.7	3.7	2.0	3.7
Total Hardness (mg/l)	44.0	54.5	49.7	55.4	65.3	72.1	85.3	95.5	100.3	70.3	37.4	53.5
Calcium (mg/l)	12.6	15.0	9.5	13.1	14.2	16.5	18.7	21.8	20.5	13.1	8.4	7.9
Magnesium (mg/l)	7.6	9.5	9.7	10.2	12.4	13.5	16.1	17.9	19.8	13.6	7.0	11.0
Faecal Coliform (mg/l)	132	140	148	150	146	138	134	152	156	162	133	131

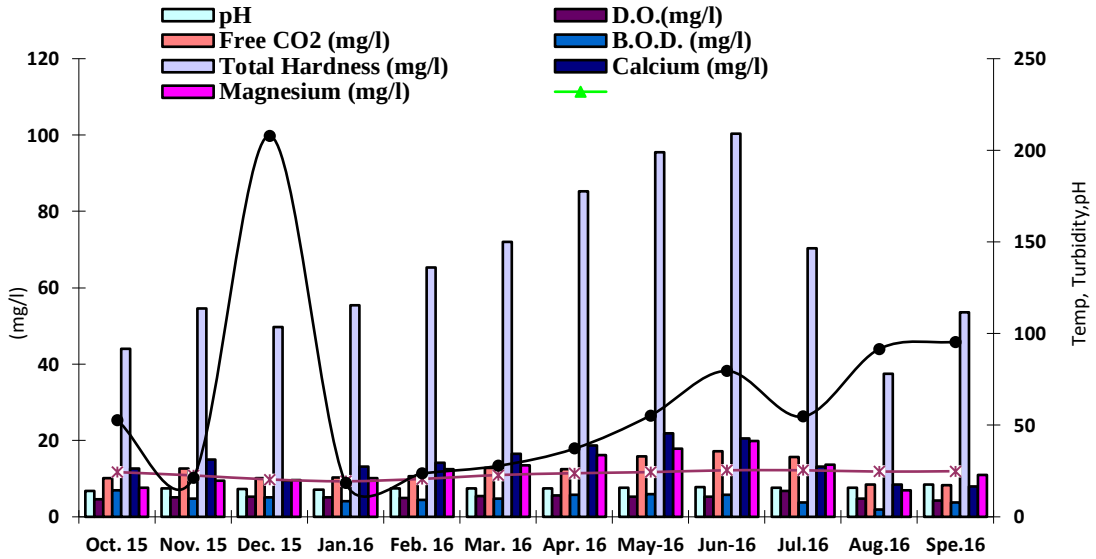

Fig. 4.2.7a: Analysis Physico-chemical and biological parameters of the water of Maha River, Chandel District (October 2015 to September 2016)

Table 4.2.7.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The water temperature of Maha River was recorded with a range of 22.6^0c (November) to 24.9^0c (September), turbidity with a range of 18.5NTU (January) to 95.5 NTU (September), p^H with a range of 6.8 (October) to 8.5 (September), dissolved oxygen with a range of 4.3 mg/l (September) to 6.4mg/l (July), free carbon dioxide with a range of 8.3 mg/l (September) to 17.2 mg/l (June), B.O.D. with a range of 2.0mg/l (August) to 6.9mg/l (October), total hardness 37.4mg/l (August) to 100.3 mg/l (June), calcium with a range of 7.9 mg/l (September) to 21.8mg/l (May), magnesium with a range of 7.0 mg/l (August) to 19.3mg/l (June), faecal coliform with a range of 131 mg/l (September) to 162mg/l (July).

The water temperature of Maha River was recorded with a range of 19.3°c (January) to 25.6°c (September), turbidity with a range of 18.6 NTU (January) to 95.2 NTU (June), pH with a range of 6.3 (October) to 8.3 (September), dissolved oxygen with a range of 4.4 mg/l (September) to 6.2 mg/1 (July), free carbon dioxide with a range of 8.2 mg/l (September) to 17.5 mg/I(June), B.O.D. with a range of 2.3 mg/l (August) to 6.8 mg/l (October), total hardness 37.6 mg/l (August) to 100.1 mg/1 (June),

calcium with a range of 7.7 mg/l (September) to 21.7 mg/l (May), magnesium with a range of 7.0 mg/l (August) to 19.4 mg/l (June), faecal coliform with a range of 128 mg/1 (October) to 163 mg/I(July). (Table 4.2.7.b). It is graphically displayed in Fig. 4.2.7.b.

Table 4.2.7.b: Analysis Physico –chemical and biological parameters of the water of Maha River, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	24.5	22.2	20.1	19.3	20.8	22.6	23.7	24.3	25.6	25.4	24.2	24.8
Turbidity (NTU)	52.5	21.7	20.4	18.6	23.5	27.6	37.1	55.2	79.4	54.2	90.9	95.2
pH	6.3	7.4	7.2	7.4	7.5	7.7	7.6	7.5	7.5	7.4	7.7	8.3
D.O.(mg/l)	4.7	5.0	5.0	5.3	5.2	5.3	5.6	5.3	5.0	6.2	4.6	4.4
Free CO_2 (mg/l)	10.2	12.4	10.1	10.4	10.4	12.9	12.4	15.2	17.5	15.6	8.2	8.2
B.O.D. (mg/l)	6.8	4.6	5.0	4.3	4.6	4.7	5.5	5.4	5.2	3.8	2.3	3.5
Total Hardness (mg/l)	43.8	54.3	48.9	55.2	65.2	72.4	85.0	95.0	100.1	70.5	37.6	53.2
Calcium (mg/l)	12.9	14.8	9.3	13.3	14.0	16.2	18.2	21.7	20.2	13.3	8.5	7.7
Magnesium (mg/l)	7.5	9.5	9.6	10.1	12.4	13.6	16.2	17.8	19.4	13.8	7.0	11.0
Faecal Coliform (mg/l)	128	138	147	152	148	140	138	150	156	163	135	135

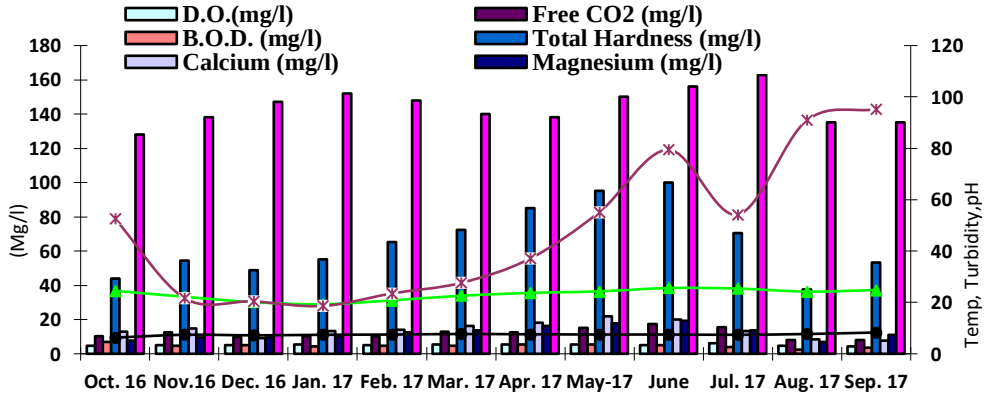

Fig. 4.2.7.b: Analysis Physico-chemical and biological parameters of the water of Maha River, Chandel District (October 2016 to September 2017)

Table 4.2.7.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of Maha River was recorded with a range of 19.3°c (January) to 25.6°c (September), turbidity with a range of 18.6 NTU (January) to 95.2 NTU (June), pH with a range of 6.3 (October) to 8.3 (September), dissolved oxygen with a range of 4.4 mg/l (September) to 6.2 mg/1 (July), free carbon dioxide

with a range of 8.2 mg/l (September) to 17.5 mg/I(June), B.O.D. with a range of 2.3 mg/l (August) to 6.8 mg/l (October), total hardness 37.6 mg/l (August) to 100.1 mg/1 (June), calcium with a range of 7.7 mg/l (September) to 21.7 mg/l (May), magnesium with a range of 7.0 mg/l (August) to 19.4 mg/l (June), faecal coliform with a range of 128 mg/1 (October) to 163 mg/I(July).

The water temperature of Maha River was recorded with a range of 19.2°c (January) to 25.8°c (June and July), turbidity with a range of 18.4 NTU (January) to 95.3 NTU (September), p^H with a range of 6.5 (October) to 8.5 (September), dissolved oxygen with a range of 4.6 mg/l (October) to 6.4 mg/1 (July), free carbon dioxide with a range of 8.5 mg/l (September) to 15.6 mg/I (May), B.O.D. with a range of 3.7 mg/l (September) to 6.7 mg/l (October), total hardness 38.4 mg/l (August) to 101.2mg/1 (June), calcium with a range of 8.2 mg/l (September) to 21.8 mg/l (May), magnesium with a range of 6.8 mg/l (August) to 19.1 mg/l (June), faecal coliform with a range of 132 mg/1 (September) to 166 mg/I(July). (Table 4.2.7.c). It is graphically displayed in Fig. 4.2.7.c.

Table 4.2.7.c: Analysis Physico –chemical and biological parameters of the water of Maha River, Chandel District (October 2017 to September 2018)

Parameters	**Oct. 17**	**Nov. 17**	**Dec. 17**	**Jan. 18**	**Feb. 18**	**Mar. 18**	**Apr. 18**	**May 18**	**June 18**	**Jul. 18**	**Aug. 18**	**Sep. 18**
Temperature	24.7	22.0	20.4	19.2	20.6	22.8	23.9	24.5	25.8	25.8	24.4	24.6
Turbidity (NTU)	52.3	21.8	20.2	18.4	23.6	27.8	37.3	55.5	79.5	54.5	90.8	95.3
pH	6.5	7.6	7.3	7.6	7.3	7.8	7.7	7.9	7.8	7.5	7.6	8.5
D.O.(mg/l)	4.6	5.0	5.2	5.5	5.4	5.6	5.7	5.4	5.3	6.4	4.7	4.8
Free CO_2 (mg/l)	10.3	12.4	10.3	10.2	10.6	13.2	12.5	15.6	13.7	15.8	8.5	8.7
B.O.D. (mg/l)	6.7	4.4	5.3	4.2	4.8	4.9	5.7	5.6	5.5	5.8	4.3	3.7
Total Hardness (mg/l)	43.9	54.5	48.7	55.4	72.5	72.3	85.3	95.6	101.2	70.8	38.1	53.5
Calcium (mg/l)	13.0	14.5	9.5	13.5	14.4	16.8	18.5	21.8	20.5	13.8	8.8	8.2
Magnesium (mg/l)	7.5	9.7	9.5	10.2	12.4	13.5	15.8	17.5	19.1	13.9	6.8	8.9
Faecal Coliform (mg/l)	132	133	145	153	152	147	144	152	157	166	138	140

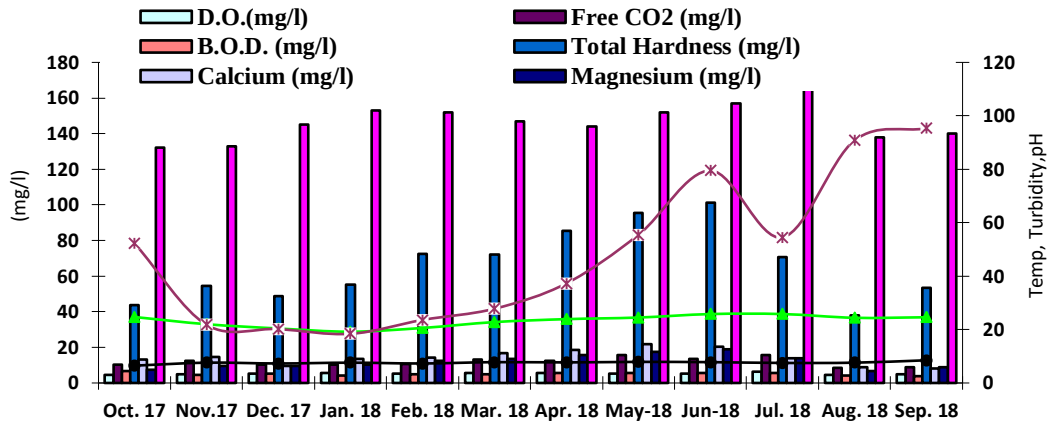

Fig. 4.2.7.c: Analysis Physico-chemical and biological parameters of the water of Maha River, Chandel District (October 2017 to September 2018)

Table 4.2.7.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The water temperature of Maha River was recorded with a range of 19.2°c (January) to 25.8°c (June and July), turbidity with a range of 18.4 NTU (January) to 95.3 NTU (September), p^H with a range of 6.5 (October) to 8.5 (September), dissolved oxygen with a range of 4.6 mg/l (October) to 6.4 mg/1 (July), free carbon dioxide with a range of 8.5 mg/l (September) to 15.6 mg/I (May), B.O.D. with a range of 3.7 mg/l (September) to 6.7 mg/l (October), total hardness 38.4 mg/l (August) to 101.2mg/1 (June), calcium with a range of 8.2 mg/l (September) to 21.8 mg/l (May), magnesium with a range of 6.8 mg/l (August) to 19.1 mg/l (June), faecal coliform with a range of 132 mg/1 (September) to 166 mg/I(July).

The water temperature of the Chakpi river ranged between 19.5°c (January) to 25.7°c (August).The minimum turbidity 18.7 NTU was observed in January and maximum 94.4NTU was observed in September. The pH of the Chakpi river ranged from 6.7 (October) to 8.4 (September). The minimum 4.5 mg/l oxygen content of water was recorded in September and maximum 6.9mg/l in July. Free CO2 fluctuated from 8.2 mg/1 (August) to 17.8 mg/l (June).The B.O.D. was minimum 3.5 mg/l in September and maximum 6.2 mg/l in October. The total hardness was highest in the month of July (99.8 mg/1) and lower in the month of August (38.2 mg/1). Maximum

concentration of calcium was found in June (20.3 mg/1) and minimum (8.0 mg/1) in September. Similarly, maximum concentration of magnesium 19.5 mg/1 was found in June and minimum 7.1 mg/l in August. Total faecal coliform was observed maximum 17.0 mg/l in July and minimum 13.5 mg/1 in September. The values of different water parameters were displayed in table 4.2.8.a and Fig 4.2.8.a.

Table 4.2.8.a: Analysis Physico –chemical and biological analysis of Chakpi River, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	24.3	22.7	20.5	19.5	20.6	22.7	23.8	24.5	25.4	25.5	25.7	24.8
Turbidity (NTU)	51.9	20.8	20.9	15.7	23.5	27.8	36.8	55.1	75.8	54.8	90.8	94.4
pH	6.7	7.3	7.4	7.1	7.5	7.4	7.6	7.6	7.8	7.5	7.6	8.4
D.O.(mg/l)	5.1	5.3	5.2	5.1	5.2	5.3	5.5	5.8	5.9	6.9	4.7	4.5
Free CO_2 (mg/l)	10.5	12.4	10.5	10.4	10.5	13.0	12.8	13.2	17.8	15.5	8.2	5.8
B.O.D. (mg/l)	6.2	4.5	5.5	4.3	4.9	4.8	5.5	5.9	5.7	4.2	3.8	3.5
Total Hardness (mg/l)	54.2	52.0	49.6	54.4	65.2	71.8	82.2	94.9	99.8	80.3	38.2	53.7
Calcium (mg/l)	13.5	14.5	9.8	13.5	14.8	16.2	18.5	21.2	20.3	13.4	8.7	8.0
Magnesium (mg/l)	9.8	9.1	9.6	9.9	12.2	13.5	15.4	17.9	19.5	16.2	7.1	11.1
Faecal Coliform (mg/l)	14.0	14.4	14.6	15.0	14.6	13.6	13.8	15.0	15.9	17.0	13.9	13.5

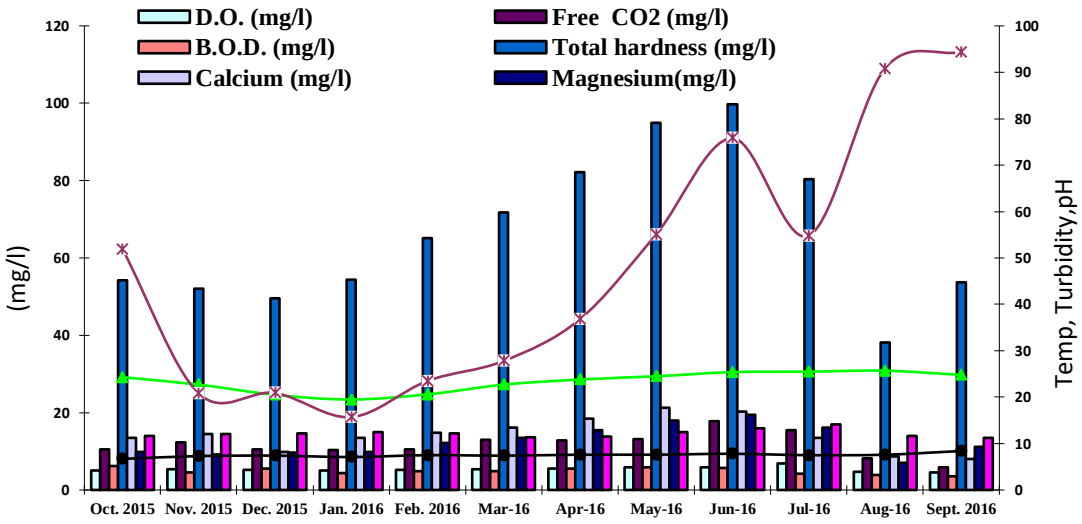

Fig. 4.2.8.a: Analysis Physico-chemical and biological parameters of the waters of Chakpi river, Chandel district (October 2015 to September 2016)

Table 4.2.8.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to

September 2016. The water temperature of the Chakpi river ranged between 19.5°c (January) to 25.7°c (August).The minimum turbidity 18.7 NTU was observed in January and maximum 94.4NTU was observed in September. The pH of the Chakpi river ranged from 6.7 (October) to 8.4 (September). The minimum 4.5 mg/l oxygen content of water was recorded in September and maximum 6.9mg/l in July. Free CO2 fluctuated from 8.2 mg/1 (August) to 17.8 mg/l (June).The B.O.D. was minimum 3.5 mg/l in September and maximum 6.2 mg/l in October. The total hardness was highest in the month of July (99.8 mg/1) and lower in the month of August (38.2 mg/1). Maximum concentration of calcium was found in June (20.3 mg/1) and minimum (8.0 mg/1) in September. Similarly, maximum concentration of magnesium 19.5 mg/1 was found in June and minimum 7.1 mg/l in August. Total faecal coliform was observed maximum 17.0 mg/l in July and minimum 13.5 mg/1 in September.

The water temperature of the Chakpi river ranged between 19.3°c (January) to 25.6°c (August).The minimum turbidity 15.2 NTU was observed in January and maximum 94.2 NTU was observed in September. The pH of the Chakpi river ranged from 6.8 (October) to 8.5 (September). The minimum 4.6 mg/l oxygen content of water was recorded in August and September and maximum 6.4mg/l in July. Free CO_2 fluctuated from 5.6 mg/1 (September) to 17.6 mg/l (June).The B.O.D. was minimum 3.7 mg/l in September and maximum 6.4 mg/l in October. The total hardness was highest in the month of June (99.2 mg/1) and lower in the month of August (38.5 mg/1). Maximum concentration of calcium was found in May (21.5 mg/1) and minimum (8.4 mg/1) in September. Similarly, maximum concentration of magnesium 19.0 mg/1 was found in June and minimum 7.1 mg/l in August. Total faecal coliform was observed maximum 17.3 mg/l in July and minimum 13.4 mg/1 in March. The values of different water parameters were displayed in table 4.2.8.b and Fig 4.2.8.b.

Table 4.2.8.b. Analysis of Physico –chemical and biological analysis of Chakpi River, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	24.2	22.8	20.6	19.3	20.7	22.6	23.6	24.2	25.2	25.3	25.6	24.6
Turbidity (NTU)	51.9	20.9	20.7	15.2	23.4	27.4	36.6	55.4	75.6	54.6	90.2	94.2
pH	6.8	7.4	7.6	7.3	7.6	7.5	7.6	7.7	7.9	7.4	7.4	8.5
D.O.(mg/l)	5.3	5.5	5.3	5.2	5.4	5.5	5.7	5.5	5.8	6.4	4.6	4.6
Free CO_2 (mg/l)	10.6	12.5	10.8	10.6	10.2	13.2	12.6	13.4	17.6	15.2	8.4	5.6
B.O.D. (mg/l)	6.4	4.6	5.7	4.4	4.6	4.9	5.7	5.7	5.5	4.4	3.9	3.7
Total Hardness (mg/l)	53.1	52.3	49.4	54.3	65.5	71.4	82.4	94.2	99.2	80.5	38.5	53.6
Calcium (mg/l)	13.6	14.8	10.4	13.8	14.9	16.6	18.7	21.5	20.8	13.9	8.9	8.4
Magnesium (mg/l)	9.5	9.1	9.4	9.8	12.2	13.3	15.4	17.6	19.0	16.1	7.1	10.9
Faecal Coliform (mg/l)	142	14.0	14.4	15.2	14.8	13.4	13.7	15.2	15.4	17.3	13.6	13.8

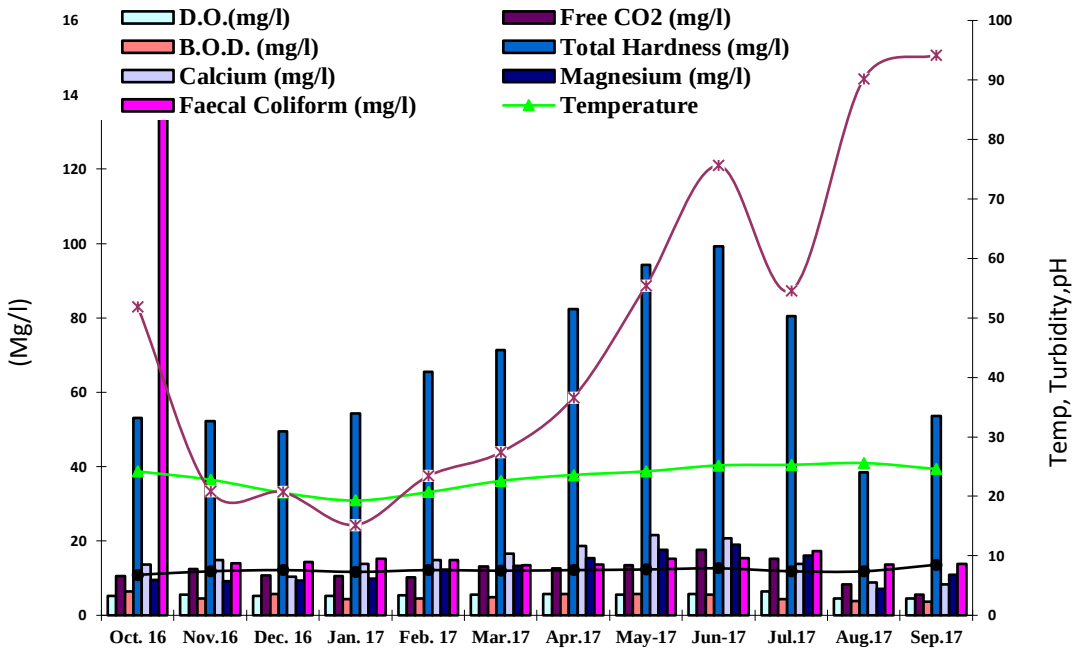

Fig. 4.2.8.b: Analysis Physico-chemical and biological parameters of the waters of Chakpi river, Chandel district (October 2016 to September 2017)

Table 4.2.8.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of the Chakpi river ranged between 19.3°c (January) to 25.6°c (August).The minimum turbidity 15.2 NTU was observed in January and maximum 94.2 NTU was observed in September. The pH of the Chakpi river ranged from 6.8 (October) to 8.5 (September). The minimum 4.6 mg/l oxygen content of water was recorded in August and September and maximum 6.4mg/l in July.

Free CO_2 fluctuated from 5.6 mg/1 (September) to 17.6 mg/l (June).The B.O.D. was minimum 3.7 mg/l in September and maximum 6.4 mg/l in October. The total hardness was highest in the month of June (99.2 mg/1) and lower in the month of August (38.5 mg/1). Maximum concentration of calcium was found in May (21.5 mg/1) and minimum (8.4 mg/1) in September. Similarly, maximum concentration of magnesium 19.0 mg/1 was found in June and minimum 7.1 mg/l in August. Total faecal coliform was observed maximum 17.3 mg/l in July and minimum 13.4 mg/1 in March.

The water temperature of the Chakpi river ranged between 19.4°C (January) to 25.8°C (August).The minimum turbidity 15.5 NTU was observed in January and maximum 94.9NTU was observed in September. The pH of the Chakpi river ranged from 6.4 (October) to 8.2 (September). The minimum 4.3 mg/l oxygen content of water was recorded in August and maximum 6.0mg/l in July. Free CO_2 fluctuated from 5.5 mg/1 (August) to 17.4 mg/l (June).The B.O.D. was minimum 3.6 mg/l in August and maximum 6.5 mg/l in October. The total hardness was highest in the month of June (99.5 mg/1) and lower in the month of August (38.2 mg/1). Maximum concentration of calcium was found in May (21.7 mg/1) and minimum (8.7 mg/1) in September. Similarly, maximum concentration of magnesium 19.0 mg/1 was found in June and minimum 7.0 mg/l in August. Total faecal coliform was observed maximum 16.9 mg/l in July and minimum 13.2 mg/1 in September. The values of different water parameters were displayed in table 4.2.8.c and Fig 4.2.8.c.

Table 4.2.8.c: Physico –chemical and biological analysis of Chakpi River, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	24.5	22.9	20.8	19.4	20.6	22.8	23.8	24.3	25.4	25.0	25.8	24.5
Turbidity (NTU)	51.6	20.8	20.6	15.5	23.3	27.3	36.4	54.9	75.8	53.8	89.9	94.9
pH	6.4	7.5	7.4	7.4	7.7	7.6	7.7	7.6	8.0	7.2	7.2	8.2
D.O.(mg/l)	5.2	5.4	5.5	5.3	5.6	5.8	5.8	5.6	5.2	6.0	4.3	4.8
Free CO_2 (mg/l)	10.8	12.2	10.9	10.8	10.4	13.5	12.6	13.8	17.4	15.4	8.2	5.5
B.O.D. (mg/l)	6.5	4.5	5.8	4.6	4.7	4.7	5.9	5.6	5.4	4.8	3.6	3.9
Total Hardness (mg/l)	53.4	52.4	49.6	54.5	65.4	72.1	82.5	95.0	99.5	80.7	38.2	54.0
Calcium (mg/l)	13.9	16.2	10.8	13.3	13.7	16.8	18.9	21.7	21.2	13.8	9.1	8.7
Magnesium (mg/l)	9.5	9.0	9.4	10.0	12.5	13.4	15.5	17.8	19.0	16.2	7.0	11.0
Faecal Coliform (mg/l)	14.3	14.5	14.8	15.3	14.9	14.0	14.2	15.4	15.6	16.9	13.4	13.2

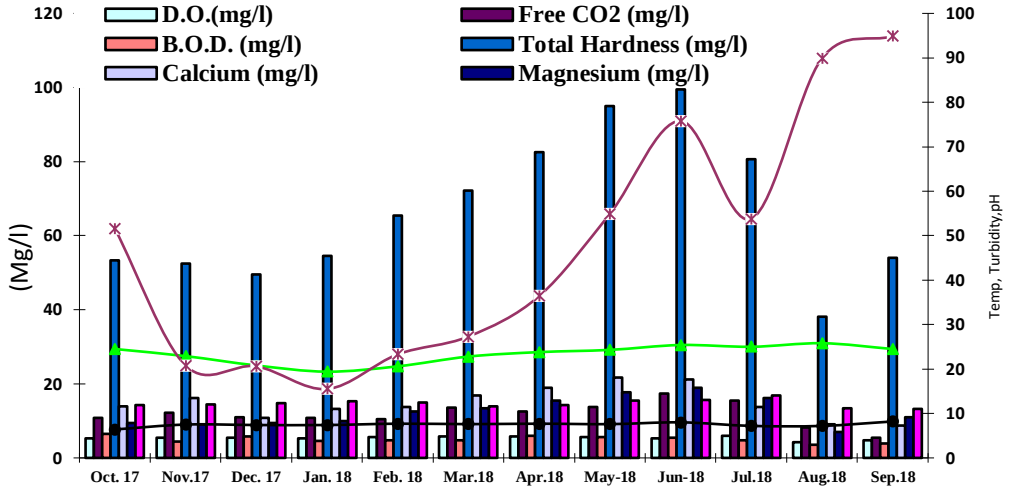

Fig. 4.2.8c: Analysis Physico-chemical and biological parameters of the waters of Chakpi river, Chandel district (October 2016 to September 2017)

Table 4.2.8.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of the Chakpi river ranged between 19.4°C (January) to 25.8°C (August).The minimum turbidity 15.5 NTU was observed in January and maximum 94.9NTU was observed in September. The pH of the Chakpi river ranged from 6.4 (October) to 8.2 (September). The minimum 4.3 mg/l oxygen content of water was recorded in August and maximum 6.0mg/l in July. Free CO_2 fluctuated from 5.5 mg/1 (August) to 17.4 mg/l (June).The B.O.D. was minimum 3.6 mg/l in August and maximum 6.5 mg/l in October. The total hardness was highest in the month of June (99.5 mg/1) and lower in the month of August (38.2 mg/1). Maximum concentration of calcium was found in May (21.7 mg/1) and minimum (8.7 mg/1) in September. Similarly, maximum concentration of magnesium 19.0 mg/1 was found in June and minimum 7.0 mg/l in August. Total faecal coliform was observed maximum 16.9 mg/l in July and minimum 13.2 mg/1 in September.

The water temperature of Machi River recorded 19.3°c (minimum) in January and 25.5°c (Maximum) in June. The turbidity ranged between 18.3 NTU (January) to 95.4 NTU (August). The p^H of the Machi river ranged from 6.7 (October) to 8.2 (September). The maximum D.O. was observed in July (6.7 mg/1) and minimum 4.5 mg/1 in October. Free CO_2 fluctuated from 8.4 mg/l (September) to 17.0 mg/1 (June).

The B.O.D. was maximum 6.7 mg/l in October and minimum 2.2 mg/1 in August. The total hardness was higher in the month of June (100.2 mg/1) and lower in the month of August (37.2 mg/1). The maximum concentration of calcium was observed in May (20.9 mg/1) and minimum 8.7 mg/1 in August and the maximum concentration of magnesium 20.9 mg/1 in June and minimum concentration 7.0 mg/1 in August. The total faecal coliform ranged between 13.2 mg/1(August) to 16.0 mg/1 (September). The data were displayed in Table 4.2.9.a and Fig. 4.2.9.a.

Table 4.2.9.a: Analysis Physico –chemical and biological parameters of the Machi River, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	24.2	22.5	20.5	19.3	20.6	20.7	23.8	24.3	25.5	25.3	24.6	24.8
Turbidity (NTU)	52.7	21.0	20.6	18.3	23.9	37.0	55.2	79.5	54.8	91.7	95.4	92.2
pH	6.7	7.4	7.3	7.3	7.4	7.4	7.5	7.5	7.7	7.6	7.8	8.2
D.O.(mg/l)	4.5	5.1	5.1	5.0	5.1	5.6	5.6	5.3	5.2	6.7	4.8	4.6
Free CO_2 (mg/l)	10.2	12.4	10.0	10.1	10.3	12.8	12.8	15.7	17.0	15.6	8.5	8.4
B.O.D. (mg/l)	6.7	4.9	5.3	4.2	4.6	5.7	5.7	5.9	5.6	3.9	2.2	3.7
Total Hardness (mg/l)	42.8	52.3	48.7	54.6	65.3	84.9	84.9	94.8	100.2	70.8	37.9	53.8
Calcium (mg/l)	13.0	15.2	10.2	12.8	13.4	17.8	17.8	20.9	14.0	9.2	8.7	7.8
Magnesium (mg/l)	7.2	9.0	9.3	10.1	12.6	16.3	16.3	17.9	20.9	14.9	7.0	11.7
Faecal Coliform (mg/l)	13.8	14.2	15.7	15.9	13.6	13.4	13.4	15.5	16.8	13.4	13.2	16.0

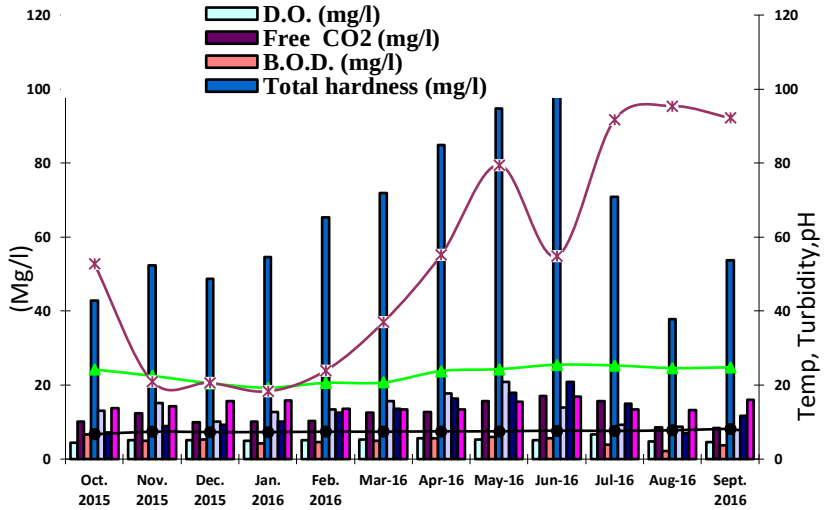

Fig. 4.2.9.a: Analysis Physico-chemical and biological parameters of the waters of Machi river, Chandel district (October 2015 to September 2016)

Table 4.2.9.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The water temperature of Machi River recorded 19.3°c (minimum) in January and 25.5°c (Maximum) in June. The turbidity ranged between 18.3 NTU (January) to 95.4 NTU (August). The p^H of the Machi river ranged from 6.7 (October) to 8.2 (September). The maximum D.O. was observed in July (6.7 mg/1) and minimum 4.5 mg/1 in October. Free CO_2 fluctuated from 8.4 mg/l (September) to 17.0 mg/1 (June). The B.O.D. was maximum 6.7 mg/l in October and minimum 2.2 mg/1 in August. The total hardness was higher in the month of June (100.2 mg/1) and lower in the month of August (37.2 mg/1). The maximum concentration of calcium was observed in May (20.9 mg/1) and minimum 8.7 mg/1 in August and the maximum concentration of magnesium 20.9 mg/1 in June and minimum concentration 7.0 mg/1 in August. The total faecal coliform ranged between 13.2 mg/1(August) to 16.0 mg/1 (September).

The water temperature of Machi River recorded 19.2°c (minimum) in January and 25.4°c (Maximum) in June. The turbidity ranged between 18.1 NTU (January) to 95.2 NTU (August). The pH of the Machi river ranged from 6.5 (October) to 8.3 (September). The maximum D.O. was observed in July (6.8 mg/1) and minimum 4.3 mg/1 in September. Free CO_2 fluctuated from 8.2 mg/l (September) to 17.2 mg/1 (June). The B.O.D. was maximum 6.8 mg/l in October and minimum 2.3 mg/1 in August. The total hardness was higher in the month of June (98.9 mg/1) and lower in the month of August (37.8 mg/1). The maximum concentration of calcium was observed in May (20.5 mg/1) and minimum 7.5 mg/1 in September and the maximum concentration of magnesium 20.5 mg/1 in June and minimum concentration 7.0 mg/1 in October and August. The total faecal coliform ranged between 13.0 mg/1(July) to 16.7 mg/1 (June). The data were displayed in Table 4.2.9.b and Fig. 4.2.9.b.

Table 4.2.9b: Analysis of Physico-chemical and biological parameters of the Machi River, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	24.4	22.4	20.6	19.2	20.4	20.6	23.8	24.2	25.4	25.2	24.5	24.8
Turbidity (NTU)	52.4	21.2	20.8	18.1	22.9	37.2	55.2	79.4	54.4	91.5	95.2	92.0
pH	6.5	7.3	7.1	7.4	7.6	7.4	7.5	7.2	7.6	7.4	7.6	8.3
D.O.(mg/l)	4.7	5.0	5.3	5.2	5.4	5.5	5.5	5.3	5.2	6.8	4.5	4.3
Free CO_2 (mg/l)	10.3	12.3	10.2	10.3	10.3	12.4	12.6	15.5	17.2	15.5	8.5	8.2
B.O.D. (mg/l)	6.8	4.8	5.3	4.3	4.5	4.8	5.6	5.7	5.4	3.8	2.3	3.7
Total Hardness (mg/l)	42.4	52.4	48.5	54.4	65.3	71.4	84.2	94.3	98.9	70.6	37.8	53.8
Calcium (mg/l)	13.3	15.6	10.8	13.2	13.6	15.8	16.	20.5	14.5	9.6	8.9	7.5
Magnesium (mg/l)	7.0	8.9	9.1	10.0	12.5	13.5	16.3	17.9	20.5	14.87	7.0	11.2
Faecal Coliform (mg/l)	13.6	14.0	15.8	15.7	13.8	13.8	13.6	15.4	16.7	13.0	13.3	16.2

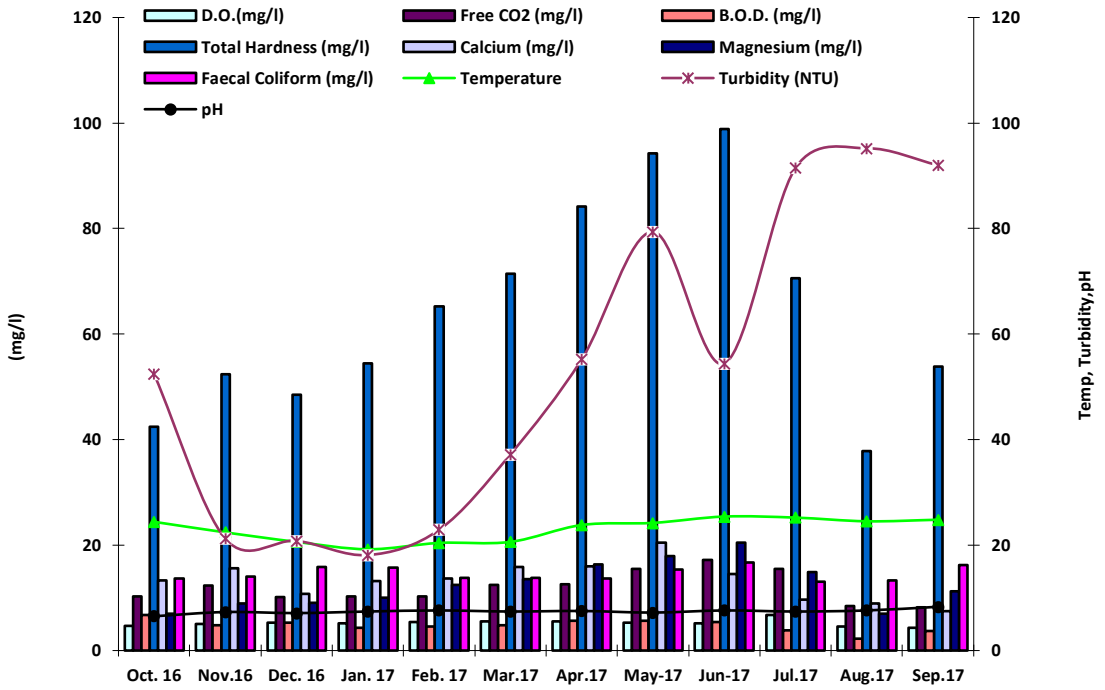

Fig. 4.2.9.b: Analysis Physico-chemical and biological parameters of the waters of Machi river, Chandel district (October 2016 to September 2017)

Table 4.2.9.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of Machi River recorded 19.2°c (minimum) in January and 25.4°c (Maximum) in June. The turbidity ranged between 18.1 NTU (January) to 95.2 NTU (August). The pH of the Machi river ranged from 6.5 (October)

to 8.3 (September). The maximum D.O. was observed in July (6.8 mg/1) and minimum 4.3 mg/1 in September. Free CO_2 fluctuated from 8.2 mg/l (September) to 17.2 mg/1 (June). The B.O.D. was maximum 6.8 mg/l in October and minimum 2.3 mg/1 in August. The total hardness was higher in the month of June (98.9 mg/1) and lower in the month of August (37.8 mg/1). The maximum concentration of calcium was observed in May (20.5 mg/1) and minimum 7.5 mg/1 in September and the maximum concentration of magnesium 20.5 mg/1 in June and minimum concentration 7.0 mg/1 in October and August. The total faecal coliform ranged between 13.0 mg/1(July) to 16.7 mg/1 (June).

The water temperature of Machi River recorded 19.4°c (minimum) in January and 25.6°C (Maximum) in June and July. The turbidity ranged between 18.2 NTU (January) to 95.3 NTU (August). The pH of the Machi river ranged from 6.5 (October) to 8.4 (September). The maximum D.O. was observed in July (6.9 mg/1) and minimum 4.5 mg/1 in September. Free CO_2 fluctuated from 8.2 mg/l (September) to 17.4 mg/1 (June). The B.O.D. was maximum 6.9 mg/l in October and minimum 2.8 mg/1 in August. The total hardness was higher in the month of June (98.9 mg/1) and lower in the month of August (37.8 mg/1). The maximum concentration of calcium was observed in May (20.7 mg/1) and minimum 8.7 mg/1 in August and the maximum concentration of magnesium 20.9 mg/1 in June and minimum concentration 7.0 mg/1 in August. The total faecal coliform ranged between 13.3 mg/1(July) to 16.6 mg/1 (June). The data were displayed in Table 4.2.9.c and Fig. 4.2.9.c.

Table 4.2.9c: Analysis of Physico-chemical and biological parameters of the Machi River, Chandel District (October 2017 to September 2018)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	24.3	22.6	20.5	19.4	20.2	20.8	23.9	24.4	25.6	25.6	24.6	24.4
Turbidity (NTU)	53.6	21.3	20.6	18.2	22.8	37.4	55.4	79.5	54.6	91.2	95.3	92.1
pH	6.5	7.4	7.2	7.5	7.5	7.6	7.7	7.3	7.5	7.4	7.8	8.4
D.O.(mg/l)	4.8	5.3	5.5	5.3	5.3	5.6	5.6	5.3	5.3	6.9	4.6	4.5
Free CO_2 (mg/l)	10.2	12.0	10.2	10.5	10.5	12.5	12.8	15.6	17.4	15.7	8.7	8.2
B.O.D. (mg/l)	6.9	5.0	5.4	4.3	4.5	4.8	5.6	5.6	5.8	3.9	2.8	3.4
Total Hardness (mg/l)	42.7	52.3	48.7	54.7	65.2	72.8	84.3	94.5	98.9	70.9	37.8	53.6
Calcium (mg/l)	13.6	15.9	11.2	13.5	13.8	15.9	16.5	20.7	14.8	9.9	9.2	7.7
Magnesium (mg/l)	7.0	8.9	9.1	10.0	12.4	13.8	16.4	17.9	20.4	14.8	6.9	11.1
Faecal Coliform (mg/l)	13.4	14.3	15.7	15.9	13.8	13.9	13.4	15.2	16.6	13.3	13.5	16.4

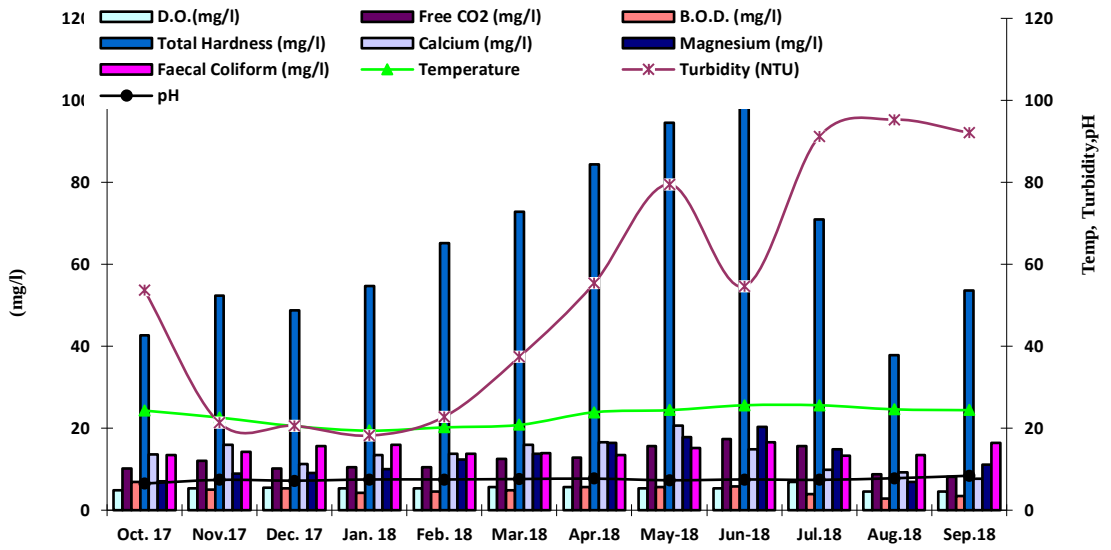

Fig. 4.2.9.c: Analysis Physico-chemical and biological parameters of the waters of Machi river, Chandel district (October 2017 to September 2018)

Table 4.2.9.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The water temperature of Machi River recorded 19.4°c (minimum) in January and 25.6°C (Maximum) in June and July. The turbidity ranged between 18.2 NTU (January) to 95.3 NTU (August). The pH of the Machi river ranged from 6.5 (October) to 8.4 (September). The maximum D.O. was observed in July (6.9 mg/1) and minimum 4.5 mg/1 in September. Free CO_2 fluctuated from 8.2 mg/l (September) to 17.4 mg/1 (June). The B.O.D. was maximum 6.9 mg/l in October and minimum 2.8 mg/1 in August. The total hardness was higher in the month of June (98.9 mg/1) and lower in the month of August (37.8 mg/1). The maximum concentration of calcium was observed in May (20.7 mg/1) and minimum 8.7 mg/1 in August and the maximum concentration of magnesium 20.9 mg/1 in June and minimum concentration 7.0 mg/1 in August. The total faecal coliform ranged between 13.3 mg/1(July) to 16.6 mg/1 (June).

The water temperature of pond recorded 19.5°c (minimum) in February and 23.9°c (Maximum) in July. The turbidity ranged between 6.8 NTU (February) to 8.9 NTU (July). The pH of the pond ranged from 6.3 (June) to 7.5 (December). The

maximum D.O. was observed in December (8.2 mg/1) and minimum 5.6 mg/1 in October. Free CO_2 fluctuated from 4.5 mg/1 (February) to 7.7 mg/l (July). The B.O.D. was maximum 9.4 mg/1 in Oct. and minimum 7.1 mg/1 in July. The total hardness was higher in the month of March (14.2 mg/1) and lower in the month of December (8.2mg/1). The maximum concentration of calcium was observed in Oct. (25.6 mg/1) and minimum 12.0 mg/1 in December and the maximum concentration of magnesium 3.4 mg/1 in October & June and minimum concentration 0.1 mg/l in April. The total faecal coliform ranged between 38 mg/I(October) to 62 mg/l (September). The data were displayed in Table 4.2. 10.a and Fig. 4.2.10.b.

Table 4.2.10.a: Analysis Physico –chemical and biological parameters of the water of Pond, Chandel District (October 2015 to September 2016)

Parameters	Oct. 2015	No. 2015	Dec. 2015	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	Jul. 2016	Aug. 2016	Sep. 2016
Temperature	23.8	22.7	20.5	18.9	19.5	20.16	22.4	23.6	23.0	23.8	23.8	23.7
Turbidity (NTU)	7.5	7.2	6.9	7.1	6.8	8.1	7.7	7.8	8.8	8.9	7.6	7.5
pH	6.5	6.4	7.5	7.0	7.2	6.6	6.7	6.4	6.3	6.4	7.2	7.3
D.O.(mg/l)	5.6	6.5	8.2	8.0	7.6	7.8	6.9	6.7	5.8	5.9	6.4	6.9
Free CO_2 (mg/l)	8.2	8.0	7.8	7.2	6.5	6.7	8.1	7.4	7.5	8.3	8.3-0	7.4
B.O.D. (mg/l)	9.4	8.8	8.2	8.7	9.3	9.2	8.9	8.5	8.6	7.1	9.0	8.9
Total Hardness (mg/l)	11.2	14.6	8.2	11.6	13.0	14.2	12.5	13.4	9.4	11.0	11.9	12.2
Calcium (mg/l)	25.6	12.2	12.0	25.3	14.1	13.2	13.0	24.6	23.8	22.9	25.0	24.9
Magnesium (mg/l)	3.4	0.5	0.9	3.3	0.2	0.2	0.1	2.7	3.4	2.8	3.1	3.0
Faecal Coliform (mg/l)	38	42	44	45	41	43	42	44	45	57	58	62

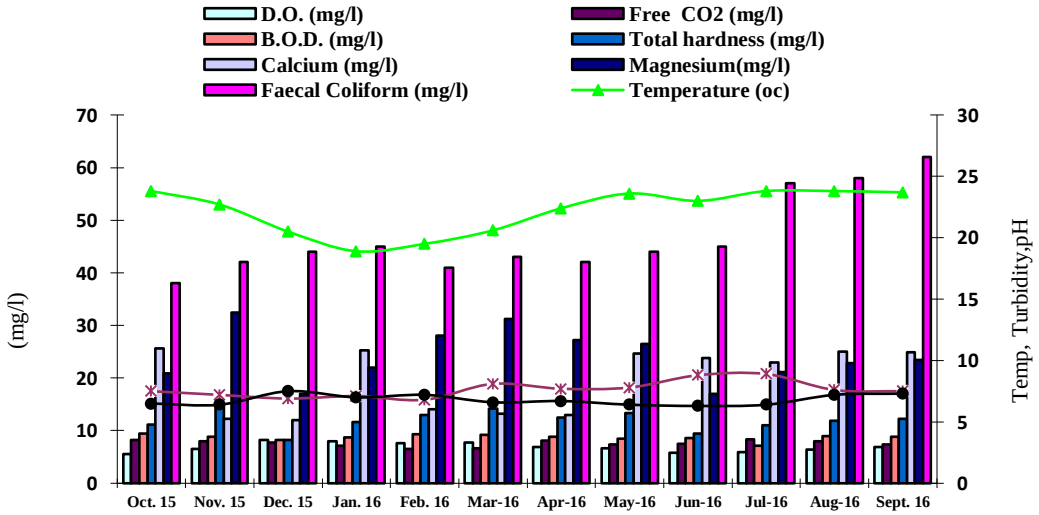

Fig. 4.2.10.a: Analysis Physico-chemical and biological parameters of the waters of pon, Chandel district (October 2015 to September 2016)

Table 4.2.10.a highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2015 to September 2016. The water temperature of pond recorded 19.5°c (minimum) in February and 23.9°c (Maximum) in July. The turbidity ranged between 6.8 NTU (February) to 8.9 NTU (July). The pH of the pond ranged from 6.3 (June) to 7.5 (December). The maximum D.O. was observed in December (8.2 mg/1) and minimum 5.6 mg/1 in October. Free CO_2 fluctuated from 4.5 mg/1 (February) to 7.7 mg/l (July). The B.O.D. was maximum 9.4 mg/1 in Oct. and minimum 7.1 mg/1 in July. The total hardness was higher in the month of March (14.2 mg/1) and lower in the month of December (8.2mg/1). The maximum concentration of calcium was observed in Oct. (25.6 mg/1) and minimum 12.0 mg/1 in December and the maximum concentration of magnesium 3.4 mg/1 in October & June and minimum concentration 0.1 mg/l in April. The total faecal coliform ranged between 38 mg/I(October) to 62 mg/l (September).

The water temperature of pond recorded 18.5°c (minimum) in January and 23.8°c (Maximum) in September. The turbidity ranged between 6.6 NTU (February) to 8.8 NTU (July). The pH of the pond ranged from 6.4 (Oct. & Sept.) to 7.5 (August). The maximum D.O. was observed in January (8.2 mg/1) and minimum 5.4 mg/1 in October. Free CO_2 fluctuated from 6.3 mg/1 (March) to 8.4 mg/l (July). The B.O.D. was maximum 9.5 mg/1 in February and minimum 3.6 mg/1 in November. The total hardness was higher in the month of April (14.5 mg/1) and lower in the month of December (8.2 mg/1). The maximum concentration of calcium was observed in Oct., Jan. and July (25.2 mg/1) and minimum 12.1 mg/1 in November and the maximum concentration of magnesium 3.4 mg/1 in October and minimum concentration 0.1 mg/l in April. The total faecal coliform ranged between 40 mg/I (October and February) to 64 mg/l (September). The data were displayed in Table 4.2. 10.b and Fig. 4.2.10.b.

Table 4.2.10b: Analysis of Physico –chemical and biological parameters of the water of Pond, Chandel District (October 2016 to September 2017)

Parameters	Oct. 16	Nov. 16	Dec. 16	Jan. 17	Feb. 17	Mar. 17	Apr. 17	May 17	June 17	Jul. 17	Aug. 17	Sep. 17
Temperature	23.6	22.9	20.8	18.5	20.0	20.4	22.2	23.5	23.2	23.6	23.9	23.8
Turbidity (NTU)	7.7	7.4	6.8	7.3	6.6	8.2	7.6	7.4	8.4	8.8	7.7	7.6
pH	6.4	6.6	7.3	7.2	7.4	6.5	6.4	6.8	6.6	6.7	7.5	7.2
D.O.(mg/l)	5.4	6.4	8.0	8.2	7.8	7.4	6.8	6.9	5.9	6.0	6.5	6.8
Free CO_2 (mg/l)	8.0	8.3	7.9	7.4	6.8	6.3	8.3	7.5	7.2	8.4	8.2	7.7
B.O.D. (mg/l)	9.2	8.9	8.3	8.6	9.5	9.4	8.8	8.3	8.4	7.3	9.2	8.5
Total Hardness (mg/l)	11.0	14.4	8.2	11.4	13.2	14.5	12.6	13.1	9.6	11.4	11.8	12.0
Calcium (mg/l)	25.2	12.1	15.1	25.2	14.3	13.4	13.2	24.7	23.6	22.8	25.2	24.4
Magnesium (mg/l)	3.4	0.5	1.6	3.3	0.2	0.2	0.1	2.6	3.4	2.7	3.2	3.0
Faecal Coliform (mg/l)	40	43	44	45	40	42	43	46	47	59	60	64

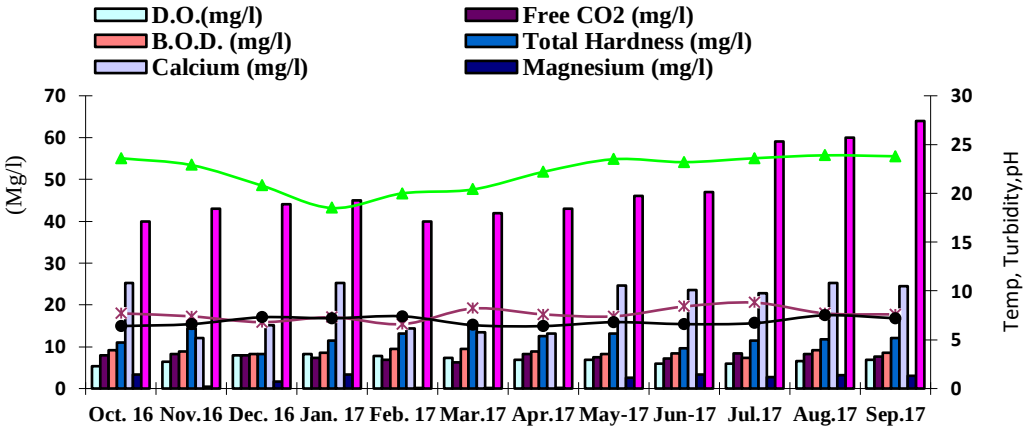

Fig. 4.2.10.b: Analysis Physico-chemical and biological parameters of the waters of pon, Chandel district (October 2016 to September 2017)

Table 4.2.10.b highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2016 to September 2017. The water temperature of pond recorded 18.5°c (minimum) in January and 23.8°c (Maximum) in September. The turbidity ranged between 6.6 NTU (February) to 8.8 NTU (July). The pH of the pond ranged from 6.4 (Oct. & Sept.) to 7.5 (August). The maximum D.O. was observed in January (8.2 mg/1) and minimum 5.4 mg/1 in October. Free CO_2 fluctuated from 6.3 mg/1 (March) to 8.4 mg/l (July). The B.O.D. was maximum 9.5 mg/1 in February and minimum 3.6 mg/1 in November. The total hardness was higher in the month of April (14.5 mg/1) and lower in the month of December (8.2 mg/1). The maximum concentration of calcium was observed in Oct., Jan. and July (25.2 mg/1) and minimum 12.1 mg/1 in November and the maximum

concentration of magnesium 3.4 mg/1 in October and minimum concentration 0.1 mg/l in April. The total faecal coliform ranged between 40 mg/I (October and February) to 64 mg/l (September).

The water temperature of pond recorded 18.2°c (minimum) in January and 23.7°c (Maximum) in October. The turbidity ranged between 6.4 NTU (February) to 8.6 NTU (July). The pH of the pond ranged from 6.2 (July) to 7.5 (September). The maximum D.O. was observed in January (8.4 mg/1) and minimum 5.2 mg/1 in October. Free CO_2 fluctuated from 6.5 mg/1 (February) to 8.5 mg/l (July). The B.O.D. was maximum 9.6 mg/1 in March and minimum 7.7 mg/1 in July. The total hardness was higher in the month of December (14.2 mg/1) and lower in the month of June (24.8 mg/1). The maximum concentration of calcium was observed in April (32.4 mg/1) and minimum 8.1 mg/1 in June and the maximum concentration of magnesium 3.2 mg/1 in October and minimum concentration 0.07 mg/l in March. The total faecal coliform ranged between 39 mg/l (February) to 86 mg/l (October). The data were displayed in Table 4.2.10.c and Fig. 4.2.10.c.

Table 4.2.10c: Analysis of Physico–chemical and biological parameters of the water of Pond, Chandel District (October 2016 to September 2017)

Parameters	Oct. 17	Nov. 17	Dec. 17	Jan. 18	Feb. 18	Mar. 18	Apr. 18	May 18	June 18	Jul. 18	Aug. 18	Sep. 18
Temperature	23.7	22.6	21.2	18.2	20.2	20.3	22.0	23.2	23.4	23.5	23.4	23.6
Turbidity (NTU)	7.6	7.3	6.6	7.0	6.4	8.4	8.3	7.0	8.5	8.6	7.2	7.4
pH	6.3	6.8	7.0	7.3	7.3	6.4	6.7	6.8	6.7	6.2	7.0	7.5
D.O.(mg/l)	5.2	6.6	8.2	8.4	7.5	7.7	7.4	7.0	5.6	5.4	6.5	6.6
Free CO_2 (mg/l)	8.2	8.2	7.5	7.5	6.5	6.8	8.4	7.7	7.3	8.5	8.0	7.5
B.O.D. (mg/l)	9.3	8.7	8.5	8.7	9.0	9.6	8.9	8.5	8.5	7.7	9.3	8.3
Total Hardness (mg/l)	11.4	13.8	14.2	12.0	13.0	13.4	13.0	13.8	9.7	11.6	11.5	12.2
Calcium (mg/l)	24.8	12.2	13.2	20.2	12.1	13.1	11.5	12.1	8.1	23.6	22.5	24.4
Magnesium (mg/l)	3.2	0.3	0.2	1.9	0.2	0.07	0.3	0.4	0.3	2.9	2.6	2.9
Faecal Coliform (mg/l)	41	43	42	48	43	47	50	54	58	62	61	67

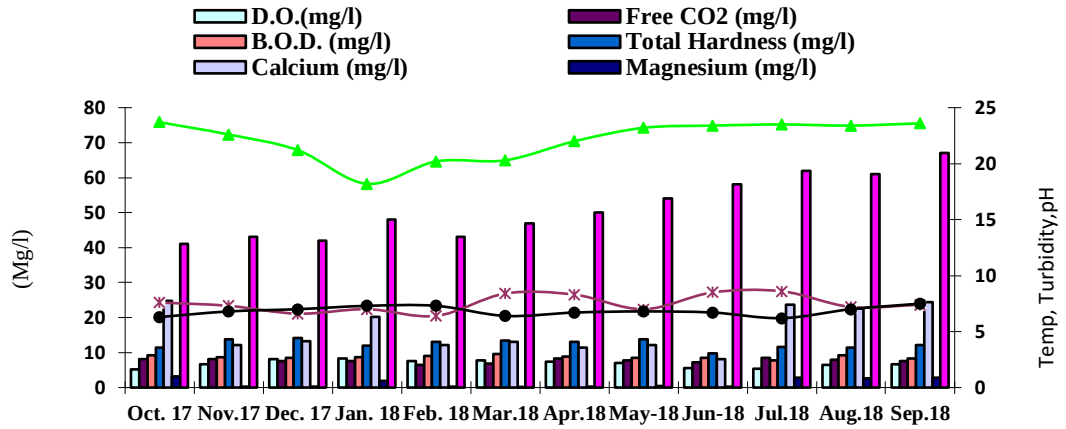

Fig. 4.2.10.c: Analysis Physico-chemical and biological parameters of the waters of pond, Chandel district (October 2017 to September 2018.

Table 4.2.10.c highlighted the various physico-chemical and biological parameters of the water of tap water of Chandel district for a period of October 2017 to September 2018. The water temperature of pond recorded 18.2°c (minimum) in January and 23.7°c (Maximum) in October. The turbidity ranged between 6.4 NTU (February) to 8.6 NTU (July). The pH of the pond ranged from 6.2 (July) to 7.5 (September). The maximum D.O. was observed in January (8.4 mg/1) and minimum 5.2 mg/1 in October. Free CO_2 fluctuated from 6.5 mg/1 (February) to 8.5 mg/l (July). The B.O.D. was maximum 9.6 mg/1 in March and minimum 7.7 mg/1 in July. The total hardness was higher in the month of December (14.2 mg/1) and lower in the month of June (24.8 mg/1). The maximum concentration of calcium was observed in April (32.4 mg/1) and minimum 8.1 mg/1 in June and the maximum concentration of magnesium 3.2 mg/1 in October and minimum concentration 0.07 mg/l in March. The total faecal coliform ranged between 39 mg/l (February) to 86 mg/l (October). Sajitha and Smitha (2016) revealed the physico-chemical parameters of 15 ponds in Athiyannoor Pan Chayath, Thiruvanthapuram District, Kerala. Various Research work has been done for the analysis of pond waters (Dwivedi and Pandey, 2002; Shrivastava and Kanungo, 2013; Jyoti, *et.al*., 2014)

Water samples were collected from nine different water bodies from Chandel district, summer season (March, April, May) winter seasons (November, December, January, February) and rainy seasons (June, July, August, September, October) with

monthly variations during October 2015 to September 2018. For physiochemical and biological analysis of different water bodies, the parameters such as temperature (^{0}C), turbidity (NTU), p^H, dissolved oxygen (D.O.) (mg/l)), biological oxygen demand (B.O.D.) (mg/l), total hardness (mg/l), Calcium (mg/l) magnesium (mg/l) were analysed (Table 4.2.11).

Table 4.2.11: Seasonal variations of the physico-chemical parameters of the different water bodies of Chandel district

Sl. No.	Parameters	Summer season	Winter Season	Rainy Season
Tap Water				
1.	Temperature(^{0}C)	21.7	20.4	22.9
2.	Turbidity (NTU)	5.6	6.0	5.9
3.	pH	8.2	6.7	6.5
4.	D.O.(mg/l)	4.4	6.0	4.9
5.	B.O.D. (mg/l)	5.2	7.6	6.4
6.	Total Hardness (mg/l)	17.3	9.0	13.6
7.	Calcium (mg/l)	15.4	15.6	13.6
8.	Magnesium	1.3	1.6	1.4
Well Water				
1.	Temperature (^{0}C)	22.4	20.1	23.8
2.	Turbidity (NTU)	3.7	2.9	5.1
3.	pH	7.7	7.8	7.9
4.	D.O.(mg/l)	5.2	5.4	5.7
5.	B.O.D. (mg/l)	2.2	2.9	2.3
6.	Total Hardness (mg/l)	55.6	62.9	57.9
7.	Calcium (mg/l)	31.2	32.6	31.7
8.	Magnesium	5.2	7.7	7.1
Hand Pump Water				
1.	Temperature (^{0}C)	22.3	20.1	23.8
2.	Turbidity (NTU)	4.4	4.2	5.1
3.	pH	7.6	7.6	8.0
4.	D.O.(mg/l)	6.8	6.8	6.7
5.	B.O.D. (mg/l)	3.8	4.7	4.5
6.	Total Hardness (mg/l)	183.7	127.7	134.0
7.	Calcium (mg/l)	26.4	21.2	14.6
8.	Magnesium	38.1	26.0	28.7
Tube Well Water				
1.	Temperature (^{0}C)	22.0	20.6	23.5
2.	Turbidity (NTU)	4.4	4.2	4.9
3.	pH	6.9	7.0	6.5

4.	D.O.(mg/l)	6.9	6.9	6.7
5.	B.O.D. (mg/l)	4.6	4.3	4.5
6.	Total Hardness (mg/l)	18.2	12.5	13.6
7.	Calcium (mg/l)	36.0	21.4	18.2
8.	Magnesium	2.3	2.1	1.1
Spring Water				
1.	Temperature (^{0}C)	22.0	21.4	23.9
2.	Turbidity (NTU)	10.0	8.5	8.4
3.	pH	6.3	5.9	5.7
4.	D.O.(mg/l)	5.1	4.6	4.7
5.	B.O.D. (mg/l)	6.0	5.7	6.0
6.	Total Hardness (mg/l)	17.4	18.8	16.9
7.	Calcium (mg/l)	11.9	11.6	11.7
8.	Magnesium	1.2	1.6	1.2
Maha River Water				
1.	Temperature (^{0}C)	23.6	16.5	24.9
2.	Turbidity (NTU)	40.0	19.4	75.3
3.	pH	7.6	7.4	7.5
4.	D.O.(mg/l)	5.4	5.1	5.0
5.	B.O.D. (mg/l)	5.3	4.6	4.6
6.	Total Hardness (mg/l)	84.2	56.6	57.0
7.	Calcium (mg/l)	18.9	12.9	12.6
8.	Magnesium	15.7	10.4	11.5
Chakpi River				
1.	Temperature (^{0}C)	23.5	20.8	25.0
2.	Turbidity (NTU)	39.7	20.1	73.3
3.	pH	7.5	7.4	7.5
4.	D.O.(mg/l)	5.6	5.3	5.3
5.	B.O.D. (mg/l)	5.4	4.8	4.7
6.	Total Hardness (mg/l)	82.9	55.3	65.1
7.	Calcium (mg/l)	18.9	13.2	13.0
8.	Magnesium	15.5	10.1	12.6
Machi River				
1.	Temperature (^{0}C)	22.9	20.6	24.8
2.	Turbidity (NTU)	57.3	20.8	71.5
3.	pH	7.4	7.3	7.7
4.	D.O.(mg/l)	5.4	5.2	5.1
5.	B.O.D. (mg/l)	5.4	4.7	4.4
6.	Total Hardness (mg/l)	77.6	55.2	55.5
7.	Calcium (mg/l)	17.8	13.2	10.7
8.	Magnesium	15.9	10.1	10.9
Pond Water				
1.	Temperature (^{0}C)	22.0	20.5	23.5
2.	Turbidity (NTU)	7.8	6.9	7.9
3.	pH	6.5	7.0	6.7

4.	D.O.(mg/l)	7.1	7.6	6.0
5.	B.O.D. (mg/l)	8.9	8.8	8.7
6.	Total Hardness (mg/l)	14.0	12.3	11.2
7.	Calcium (mg/l)	15.4	12.5	23.0
8.	Magnesium	0.74	1.09	2.8

Table 4.2.11 showed wide variation among seasons through the study period of nine different water bodies. During the study period, temperature varied from 20.4^0C (winter season) to 22.9^0C (rainy season) at the tap water. The range of water temperature of tap water was found higher in rainy season due to high air temperature. The water temperature of well varied from 23.8 ^{0}C to 20.1^0C, tube well water varied from 23.5^0C to 20.6^0C, spring water varied from 23.9^0C to 21.4^0C, Maha river varied from 24.9^0C to 16.5^0C, Chakpi river varied from 25.0^0C to 20.8^0C, Machi river varied from 24.8^0C to 20.6^0C and pond water varied from 23.5^0C to 20.5^0C.

The present observation is similar to the seasonal fluctuation in temperature studied by Sharma, 2007; Ara *et.al.* 2017; Moniruzzaman, *et.al*. 2009. The water temperature depends on a number of key components for example, wind magnitude, atmospheric temperature, solar radiation, salinity gradient and cloud coverage (Kamala *et.al*. 2007). So, maximum temperature was recorded during rainy season of all the nine different water bodies.

Turbidity of tap water varied from 5.6 NTU to 6.0 NTU, well water varied from 5.1 NTU to 2.9 NTU, hand pump varied from 5.1 NTU to 4.4 NTU, tube well varied from 4.9 NTU to 4.2 NTU, Spring water varied from 10NTU to 8.4 NTU, Maha river varied from 75.3NTU to 19.4NTU, Chakpi river varied from 73.3NTU to 20.1NTU, Machi river varied from 71.5NTU to 20.8NTU and pond water varied from 7.9NTU to 6.9NTU. The turbidity values observe in those water bodies was found to be higher during rainy season which indicates the more water mixing in the water bodies. The three rivers Maha river, Chakpi river and Machi river accorded high amount of turbidity as compared to the turbidity value of other remaining water bodies. The present finding was in concordance with the finding of Verma *et.al*. 2006 and Patil *et.al*. 2012.

pH plays a vital role to examine the water quality assessment as it has great influence on biological and chemical process is in the water body (Ahmed et.al. 2011). The pH of water collected form tap water ranged from 6.5 to 8.2, 7.7 to 7.9 in well water, 7.6 to 7.8 in hand pump water 6.5 to 7.0 in tube well water,, 5.7 to 6.3 in spring water, 7.4 to 7.6 in Maha river, 7.4 to 7.5 in Chakpi river, 7.3 to 7.7 in Machi river and 6.5 to 7.0 in pond water. The pH of water collected from different water bodies except tube well water, are all alkaline in nature which are almost equal or greater than 7.0 of the different study water bodies revealed the aerobic conditions and lesser anthropogenic sources. The lower pH value at the tube well is probably due to the concentration of dissolved substances as a result of evapo-transpiration. This was consistent with the report of Akpan (2004) for Qua Iboe river; Abowei (2010) and Charkhabi and Sakizadeh (2006).

Dissolved oxygen (D.O.) are present in water in the form of a dissolved gas. It is one of the most vital parameters in water quality assessment and reflects the physical and biological processes prevailing the water (Trivedi and Goel, 1984). The level of D.O. varied from 4.4mg/l (summer season) to 6.0 mg/l (winter season) in tap water, 5.2 mg/l (summer season) to 5.7 mg/l (rainy season) in well water, 6.7 mg/l (rainy season) to 6.8 mg/l (Summer and winter season) in handpump water, 6.7 mg/l (rainy season) to 6.9 mg/l (summer and winter season) in tube well water, 5.1mg/l (summer season) to 6.0 mg/l (rainy season) in spring water, 5.0 mg/l (rainy season) to 5.4 mg/l (summer season) in Maha river, 5.3 mg/l (winter and rainy season) to 5.6 mg/l (summer season) in Chakpi river, 5.1 mg/l (rainy season) to 5.4 mg/l (summer season) and 6.0 mg/l (rainy season) to 7.6mg/l (winter season) in pond water. The level of D.O. was found to be lower in the tap water, well water, tube well and pond water compared to the winter and rainy season due to higher rate of decomposition of organic matter and limited flow of water in a low holding environments can be noticed due to high temperature (Rani *et.al*. 2004). The higher level of D.O. in the rainy season due to the increased current flow that enables the diffusion and mixing of atmospheric oxygen into the water (Izonfuo and Bariweni, 2001).

The B.O.D. is an important parameter which indicate the decomposition and organic status of river water, during the study period, B.O.D. value ranged from 5.2 mg/l (summer season) to 7.6 mg/l (winter season) in tap water, 2.2 mg/l (summer season) to 2.9 mg/l (winter season) in well water, 3.8 mg/l (summer season) to 4.7/mg/l (winter season) in hand pump water, 4.3 mg/l (winter season) to 4.6mg/l (summer season) in tube well, 5.7 mg/l (winter season) to 6.0 mg/l (summer and rainy season) in spring water, 4.6 mg/l (winter and rainy season) to 5.3 mg/l (summer season) in Maha river, 4.7 mg/l (rainy season) to 5.4 mg/l (summer season) in Chakpi river, 4.4 mg/l (rainy season) to 5.4 mg/l (summer season) in Machi river and 8.7 mg/l (rainy season) to 8.9 mg/l (summer season) in pond water. Except tap water, tube well water and pond water, the lower value of B.O.D. are less than 5 mg/l which is permissible level of B.O.D. are accorded in the water bodies. The higher value of B.O.D. to these three water bodies indicates the hyper loading of decomposition and anaerobic oxidation in water bodies (Patil *et.al.* 2012). The value of B.O.D. is an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent (Ndimele, 2012).

Total hardness is the property of water which prevents the latter formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium and magnesium salts or both. During the present investigation, the total hardness value varied from 9.0 mg/l (winter season) to 17.3 mg/l (summer season) in the tap water, 55.6 mg/l (summer season) to 62.9 mg/l (winter season) in well water, 127.2 mg/l (winter season) to 183.7 mg/l (summer season) in hand pump water, 12.5mg/l (winter season) to 18.2mg/l (summer season) in tube well, 16.9 mg/l (rainy season) to 18.8 mg/l (winter season) in spring water, 56.6 mg/l (winter season) to 84.2 mg/l (summer season) in Maha river water, 55.3 mg/l (winter season) to 82.9 mg/l (summer season) in Chakpi river water, 55.2 mg/l (winter season) to 77.6 mg/l (summer season) in Machi river water and 11.2 mg/l (rainy season) to 14.0 mg/l (summer season) in the pond water. The total hardness of different investigated water bodies except hand pump was high during summer season than winter and rainy season. The highest amount of total hardness was recorded in the water of hand pump. These high value may be due to the addition of calcium and magnesium salts and the

high value of total hardness during summer can be attributed to decrease in water volume and increase in rate of evaporation of water. This was consistent with the report of Hujare (2008), Dhanaji *et.al*. 2016 and Nama *et.al.* (2018).

Calcium serves in our body as vascular contraction, muscle contraction, blood clotting and nerve transmission. Taking lesser amount of calcium is associated increased risk of nephrolithiasis, osteoporosis, hypertension, colorectal cancer and coronary artery diseases obesity and insulin resistance, High content of calcium and magnesium in drinking water should be avoided in the case of kidney stone or bladder stone. Calcium is an important nutrient for aquatic, organism and it is commonly present in all water bodies (Ansari and Prakash, 2000). During the present investigation, the calcium concentration varied from 13.6 mg/l (rainy season) to 15.6mg/l (winter season) in the tap water, 31.2 mg/l (summer season) to 32.6 mg/l (winter season) in well water, 14.6 mg/l (rainy season) to 26.4 mg/l (summer season) in handpump water, 18.2 mg/l (rainy season) to 36.0mg/l (summer season) in tube well water, 11.6mg/l (winter season) to 11.9 mg/l (summer season) in spring water, 12.6 mg/l (rainy season) to 18.9 mg/l (summer season) in Maha river water, 13.0 mg/l (rainy season) to 18.9 mg/l (summer season) in Chakpi river water, 10.7 mg/l (rainy season) to 17.8 mg/l (summer season) in Machi river water and 12.5 mg/l (winter season) to 23.0 mg/l (rainy season) in the pond water. Except pond water, all the other remaining eight water bodies, the concentration of calcium is higher in the summer season than that of the rainy and winter season. In the water of pond, the concentration of calcium is higher in the rainy season due to the access of discharge of the rocks in the water body. This present work is in consistent with the works of Shivakumar *et.al*. (2011), Sivamani Kandan and John (2016), Ambrasu and Anbuselvan (2017).

Magnesium is one of the important sources for chlorophyll development and it acts as a restrictive factor for the growth of phytoplankton (Dagaonkar and Saksena, 1992). Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. The concentration of magnesium ranged from 1.3 mg/l (summer season) to 1.6 mg/l (winter season) in tap water, 5.2 mg/l (summer season) to 7.7 mg/l (winter season) in well water, 26.0 mg/l

(winter season) to 38.1 mg/l (summer season) in handpump water, 1.1 mg/l (rainy season) to 2.3 mg/l (summer season) in tube well water, 1.2 mg/l (summer and rainy season) to 1.6 mg/l (winter season) in spring water, 10.4 mg/l (winter season) to 15.7 (summer season) in Maha river, 10.1 mg/l (winter season) to 15.5 mg/l (summer season) in Chakpi river, 10.1 mg/l (winter season) to 15.9 mg/l (summer season) in Machi river and 0.74 mg/l (summer season) to 2.8 mg/l (rainy season) in pond water. The least amount of magnesium concentration in all the water bodies reduces the phytoplankton population. The result agreed with those of Olusiji *et.al*. (2011) who reported a magnesium hardness of 3.4-25.9 mg/l for the water samples they examined. Drinking water with low magnesium content is harmful to human health. The minimum value is 10 mg/l. High levels of magnesium in drinking water will render such water objectionable to consumers and may even become hazardous to health. The present work is in consistent with the works of Samuel *et.al*. (2009), Saxena and Sharma (2017).

Water quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water (Asadi *et.al*., 2007 & Buchanan and Triantafilis, 2008) to the concerned citizens and policy makers. WQI is a dimensionless number that combines multiple water quality factors into a single number by normalizing values to subjective rating curves (Miller *et. al*., 1986). Factors to be included in WQI model could vary depending upon the designated water uses and local preferences. WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in the consistent manner (Hulya, 2009; Brown *et al*., 1972 (Table 4.2.12).

Table 4.2.12: Classification of water quality based on weighted arithmetic WQI method

WQI	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unsuitable for drinking

Source: Brown *et.al.,* 1972

The calculated Water Quality Index (WQI) based on observed values (V_n), standard values (S_n), Unit Weight (W_n) and quality Rating (q_n) of different water bodies of Chandel district for three different seasons like summer season, winter season and rainy seasons were displayed in table 4.2.13 to 4.2.21.

Table 4.2.13.a: Calculation of WQI in Summer Season for Tap water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	21.7	25	0.00468	86.8	0.40	
Turbidity (NTU)	5.6	5	0.0234	112.0	2.62	
pH	8.2	6.5-8.5	0.2190	80.0	17.52	86.38
D.O (mg/l)	4.4	5	0.3723	106.2	33.55	
B.O.D (mg/l)	5.2	5	0.3723	104.0	38.71	
Total Hardness (mg/l)	17.3	300	0.0062	5.7	0.035	
Calcium (mg/l)	15.4	75	0.025	20.5	0.51	
Magnesium (mg/l)	1.3	30	0.061	4.3	0.26	
			∑Wn=1.083		∑Wn=93.63	

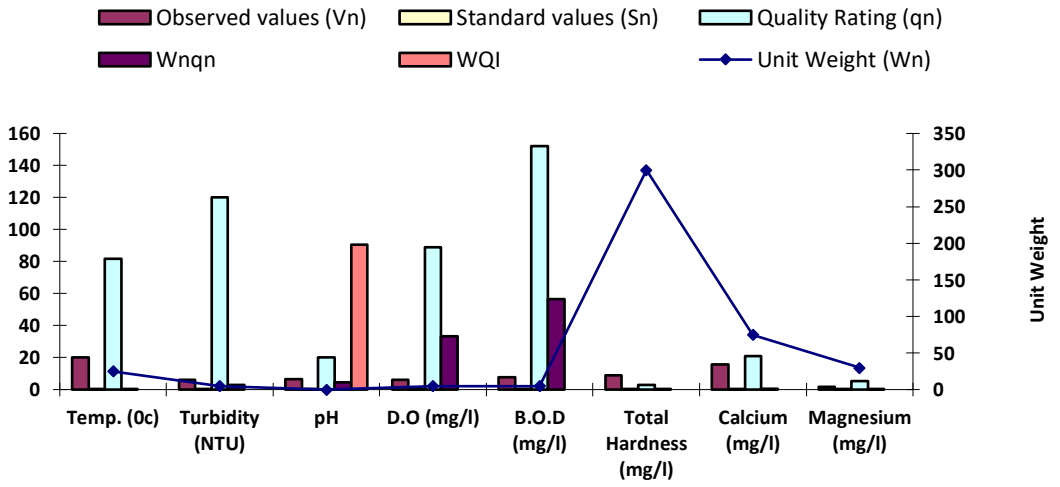

Fig 4.2.13.a: Calculation of WQI in Summer Season for Tap water

Table 4.2.13.b: Calculation of WQI in winter Season for Tap water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.4	25	0.00468	81.6	0.38	
Turbidity (NTU)	6.0	5	0.0234	120.0	2.80	
pH	6.7	6.5-8.5	0.2190	20.0	4.38	90.55
D.O (mg/l)	6.0	5	0.3723	89.0	33.13	
B.O.D (mg/l)	7.6	5	0.3723	152.0	56.58	
Total Hardness (mg/l)	9.0	300	0.0062	3.0	0.018	
Calcium (mg/l)	15.6	75	0.025	20.8	0.52	
Magnesium (mg/l)	1.6	30	0.061	5.3	0.323	
			∑Wn=1.083		∑Wnqn=98.18	

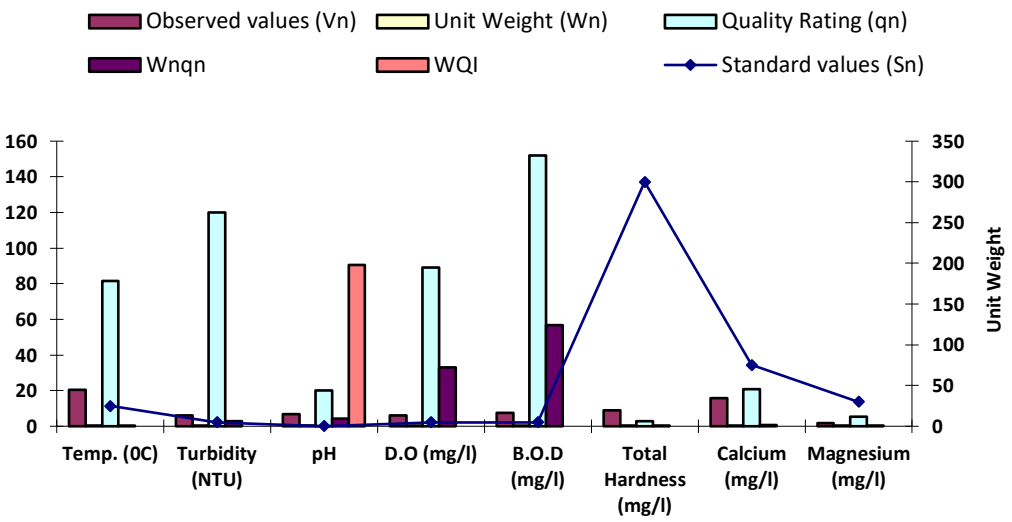

Fig. 4.2.13b: Calculation of WQI in winter Season for Tap water

Table 4.2.13.c: Calculation of WQI in Rainy Season for Tap water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.9	25	0.00468	91.6	0.42	
Turbidity (NTU)	5.9	5	0.0234	118.0	2.76	
pH	6.5	6.5-8.5	0.2190	33.3	7.29	90.55
D.O (mg/l)	4.9	5	0.3723	101.0	37.61	
B.O.D (mg/l)	6.4	5	0.3723	128.0	47.65	
Total Hardness (mg/l)	13.6	300	0.0062	4.5	0.02	
Calcium (mg/l)	13.6	75	0.025	18.1	0.45	
Magnesium (mg/l)	1.4	30	0.061	4.6	0.28	
			$\sum W_n$=1.083		$\sum W_nq_n$ =96.52	

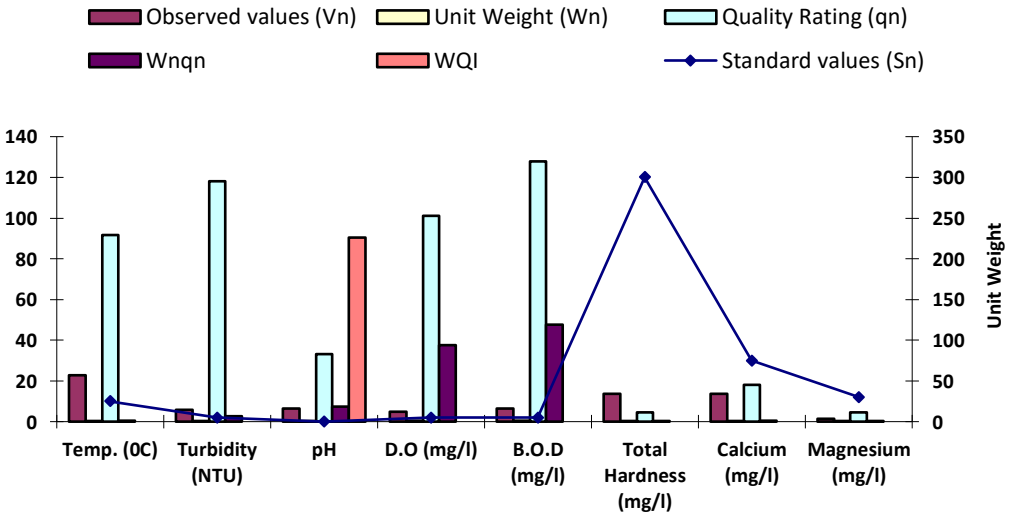

Fig. 4.2.13.c: Calculation of WQI in Rainy Season for Tap water

Table 4.2.13.a represents the observed values (V_n) of the eight (8) selected physico-chemical parameters of Tap water during summer, standard drinking water values (S_n) according to WHO, 1993; ICMR, 1975; BIS, 2021, unit weight (W_n), water quality rating (q_n) and W_nq_n during summer season from Oct. 2015 to Sept. 2018. The calculated WQI values recorded 86.38 which falls within 76-100 of the classification of water quality based on weighted arithmetic WQI method as given. It follows that untreated water from Tap water during summer season is very poor quality and must therefore be treated before use to avoid water related diseases. Table 4.2.13. b & c indicates the observed values (V_n), Standard values (S_n), Unit weight (W_n), Water quality rating (qn) and W_nq_n of the eight (8) selected physic-chemical parameters of tap water sample during winter season and rainy season respectively collected during October 2015 to September 2018. The calculated WQI values were 90.55 and 89.05 during winter and rainy seasons. The observed WQI for the tap water body in winter season and rainy season falls within 76-100 of the classification of water quality based on Table 4.2.12. This water quality rating study clearly shows that the status of the tap water body is very poor quality and it also observed that the pollution load is relatively high during winter season when compared to the summer and rainy seasons. Ambasht (1971), Sinha (1995) have also made similar observations in their studies on different water bodies.

Table 4.2.14.a: Calculation of WQI in Summer Season for Well water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.4	25	0.00468	89.6	0.41	
Turbidity (NTU)	3.7	5	0.0234	74.0	1.73	
pH	7.7	6.5-8.5	0.2190	46.6	10.20	
D.O (mg/l)	5.2	5	0.3723	97.9	36.44	62.22
B.O.D (mg/l)	2.2	5	0.3723	44.0	16.38	
Total Hardness (mg/l)	55.6	300	0.0062	18.5	0.11	
Calcium (mg/l)	31.2	75	0.025	41.6	1.04	
Magnesium (mg/l)	5.2	30	0.061	17.3	1.05	
			$\sum W_n$=1.083		$\sum W_nq_n$ =67.385	

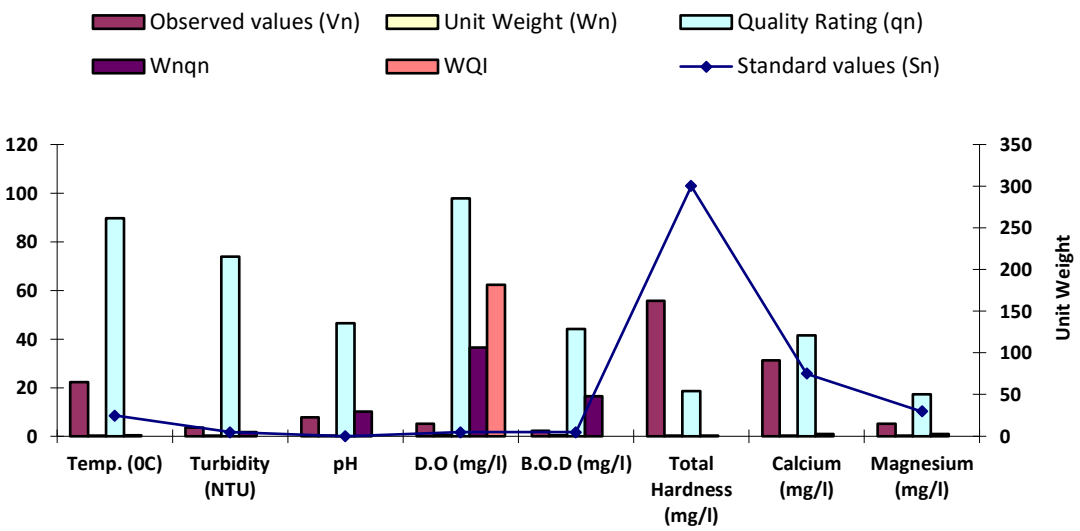

Fig. 4.2.14.a: Calculation of WQI in Summer Season for Well water

Table 4.2.14b: Calculation of WQI in Winter Season for Well water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.1	25	0.00468	80.4	0.37	
Turbidity (NTU)	2.9	5	0.0234	58.0	1.35	
pH	7.8	6.5-8.5	0.2190	53.3	11.67	
D.O (mg/l)	5.4	5	0.3723	95.8	35.67	67.18
B.O.D (mg/l)	2.9	5	0.3723	58.0	21.59	
Total Hardness (mg/l)	62.9	300	0.0062	20.9	0.12	
Calcium (mg/l)	32.6	75	0.025	43.4	1.08	
Magnesium (mg/l)	7.7	30	0.061	25.6	1.56	
			$\sum W_n$=1.083		$\sum W_nq_n$ =73.46	

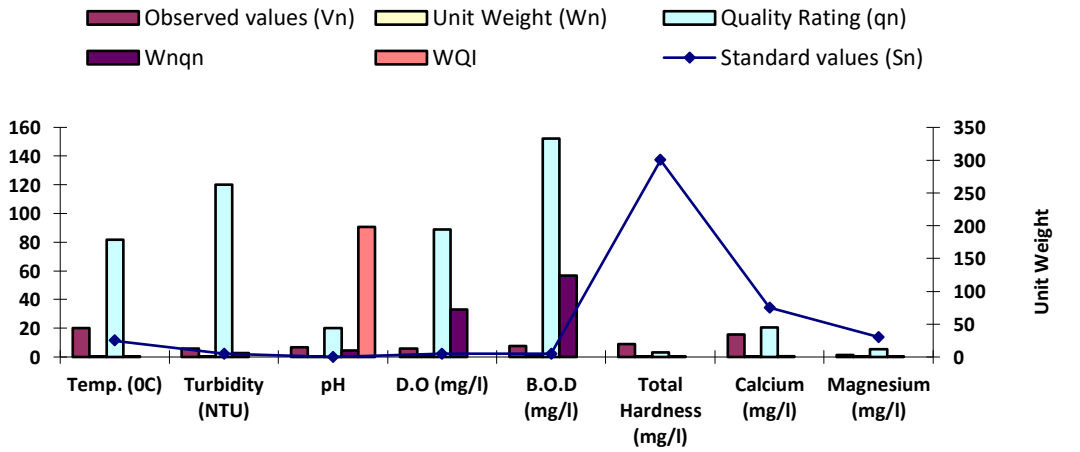

Fig.4.2.14b: Calculation of WQI in Winter Season for Well water

Table 4.2.14.c: Calculation of WQI in Rainy Season for Well water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.8	25	0.00468	95.2	0.44	
Turbidity (NTU)	5.1	5	0.0234	102.0	2.38	
pH	7.9	6.5-8.5	0.2190	60.0	13.14	
D.O (mg/l)	5.7	5	0.3723	92.1	34.5	64.80
B.O.D (mg/l)	2.3	5	0.3723	46.0	17.12	
Total Hardness (mg/l)	57.9	300	0.0062	19.3	0.11	
Calcium (mg/l)	31.7	75	0.025	42.2	1.05	
Magnesium (mg/l)	7.1	30	0.061	23.6	1.44	
			$\sum W_n$=1.083		$\sum W_nq_n$ =70.23	

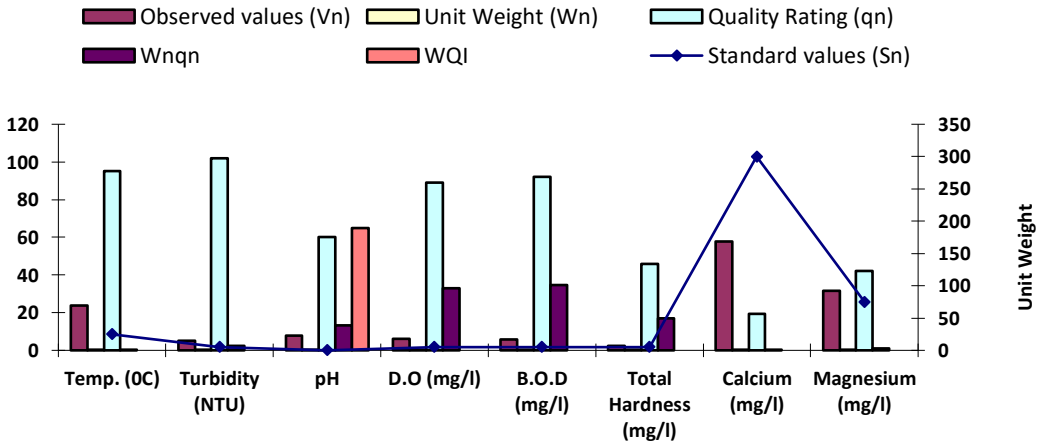

Fig.4.2.14c: Calculation of WQI in Rainy Season for Well water

Table 4.2.14 (a), (b) and (c) depicts the observed values (V_n), Standard values (S_n), Unit weight (W_n), Water quality rating (q_n) and W_nq_n of the water body of well of the eight (8) selected physic-chemical parameters of water samples collected during summer seasons, winter seasons and rainy seasons respectively during October 2015 to September 2018. The WQI obtained for the well water in different seasons of study period i.e., summer season (62.22), winter season (67.78) and rainy seasons 64.80 respectively, which indicates the values falls within 51-75 of the classification of water quality based on weighted arithmetic WQI method as given in Table 4.2.12. The present work revealed that the WQI of the well water during winter season is relatively high as compared to the values of summer seasons and rainy seasons due to the dumping of domestic

wastes and agricultural runoff as well. The observed value of WQI of different seasons also indicates that the water from the well is of poor quality and must therefore be treated before use to avoid water related diseases. Thus the well water is unsuitable for drinking and if the present state of affairs continues for long, it may soon become on ecologically dead. The present work is supported by the findings of Tripathi (2013), Chaturvedi (2010). It is in concordance with the work of Syamsir *et.al*., 2019; Bohara, 2016; Misagi *et.a*l., 2017. Moreover, Borchardt's research also revealed that four located in the vicinity of feces processing facilities had been contaminated and polluted (Kannel *et.al*. 2007).

Table 4.2.15a: Calculation of WQI in Summer Season for Handpump water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.3	25	0.00468	89.2	0.41	
Turbidity (NTU)	4.4	5	0.0234	88.0	2.05	
pH	7.6	6.5-8.5	0.2190	40.0	8.76	
D.O (mg/l)	6.8	5	0.3723	81.2	30.24	72.69
B.O.D (mg/l)	3.8	5	0.3723	76.0	28.29	
Total Hardness (mg/l)	183.7	300	0.0062	61.2	0.37	
Calcium (mg/l)	26.4	75	0.025	35.2	0.88	
Magnesium (mg/l)	38.1	30	0.061	127.0	7.74	
			$\sum W_n$=1.083		$\sum W_nq_n$ =78.78	

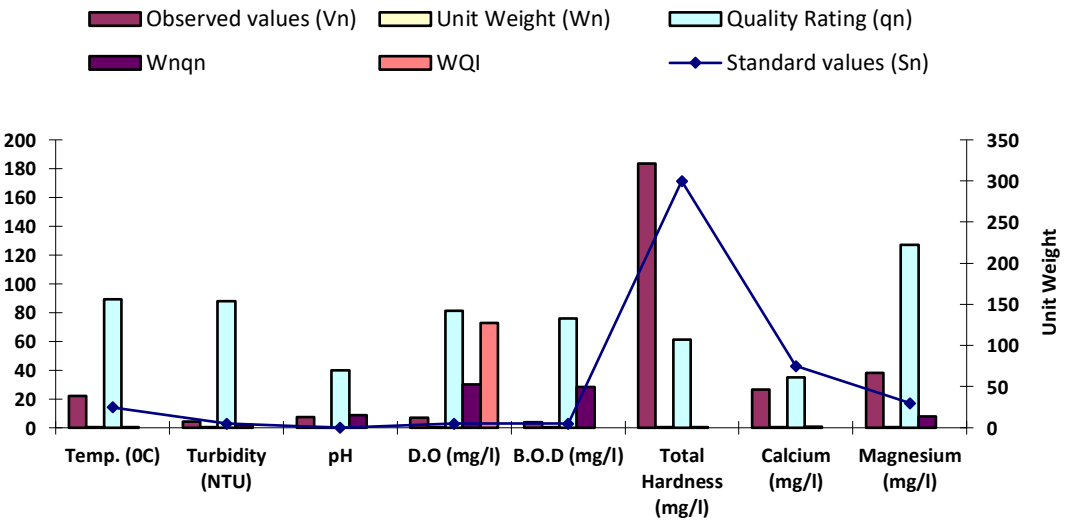

Fig. 4.2.15.a: Calculation of WQI in Summer Season for Handpump water

Table 4.2.15.b: Calculation of WQI in Winter Season for Handpump water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.1	25	0.00468	80.4	0.37	
Turbidity (NTU)	4.2	5	0.0234	84.0	1.96	
pH	7.6	6.5-8.5	0.2190	40.0	8.76	
D.O (mg/l)	6.8	5	0.3723	81.2	30.24	76.21
B.O.D (mg/l)	4.7	5	0.3723	94.0	34.99	
Total Hardness (mg/l)	127.7	300	0.0062	42.5	0.26	
Calcium (mg/l)	21.2	75	0.025	28.2	0.70	
Magnesium (mg/l)	26.0	30	0.061	86.6	5.28	
			$\sum W_n$=1.083		$\sum W_nq_n$ =82.605	

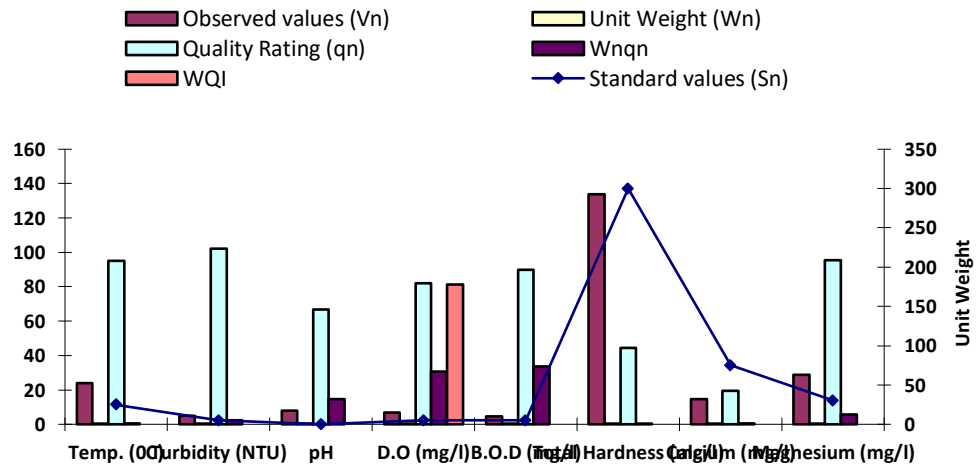

Fig. 4.2.15.b: Calculation of WQI in Winter Season for Handpump water

Table 4.2.15.c: Calculation of WQI in Rainy Season for Handpump water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.8	25	0.00468	95.2	0.44	
Turbidity (NTU)	5.1	5	0.0234	102.0	2.38	
pH	8.0	6.5-8.5	0.2190	66.6	14.60	
D.O (mg/l)	6.7	5	0.3723	82.2	30.63	81.35
B.O.D (mg/l)	4.5	5	0.3723	90.0	33.50	
Total Hardness (mg/l)	134.0	300	0.0062	44.6	0.27	
Calcium (mg/l)	14.6	75	0.025	19.4	0.48	
Magnesium (mg/l)	28.7	30	0.061	95.6	5.83	
			$\sum W_n$=1.083		$\sum W_nq_n$ =88.17	

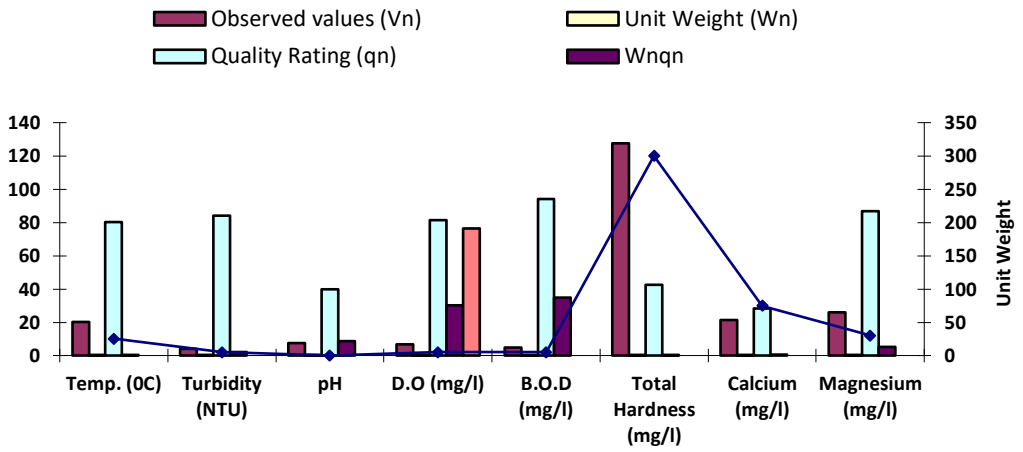

Fig. 4.2.15.c: Calculation of WQI in Rainy Season for Handpump water

Table 4.2.15.a, b & c depicts the observed values (V_n), Standard value (S_n), Unit weight (W_n), Quality rating (q_n) and W_nq_n of the three different seasons during October. 2015 to September 2018 of the handpump waters of the eight (8) selected physico-chemical parameters of the Chandel district. The WQI of the handpump water was then calculated using the weighted arithmetic index formula and observed the values 72.69 for summer seasons, 76.21 winter seasons and 81.35 and rainy seasons respectively. The values of summer season falls within 51-75 lf the classification of water quality (Brown *et.al*., 1972). This indicates that the water from the handpump is of poor quality in the summer season. On the other hand the WQI values of winter and rainy seasons falls within 76-100 which is very poor quality rating of the summer season is relative good as compared to the water quality rating of the winter and rainy seasons. The present analysis revealed that hand pump water of the Chandel district was found to unsuitable for drinking purposes so as to require proper treatment before used by local community. The present work recommend to carry and development of effective continuous water quality program and development of effective practices for utilization of drinkable water in Chandel District. The present work was in concordance with the work of Soni Singh (2015) and Tatawat and Singh (2007).

Table 4.2.16a: Calculation of WQI in Summer Season for Tube well water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.0	25	0.00468	88.0	0.41	
Turbidity (NTU)	4.4	5	0.0234	88.0	2.05	
pH	6.9	6.5-8.5	0.2190	6.6	1.46	
D.O (mg/l)	6.9	5	0.3723	80.2	29.86	63.66
B.O.D (mg/l)	4.6	5	0.3723	92.0	34.25	
Total Hardness (mg/l)	18.2	300	0.0062	6.0	0.03	
Calcium (mg/l)	36.0	75	0.025	48.0	1.20	
Magnesium (mg/l)	2.3	30	0.061	7.6	0.46	
			$\sum W_n=1.083$		$\sum W_nq_n$ =69.75	

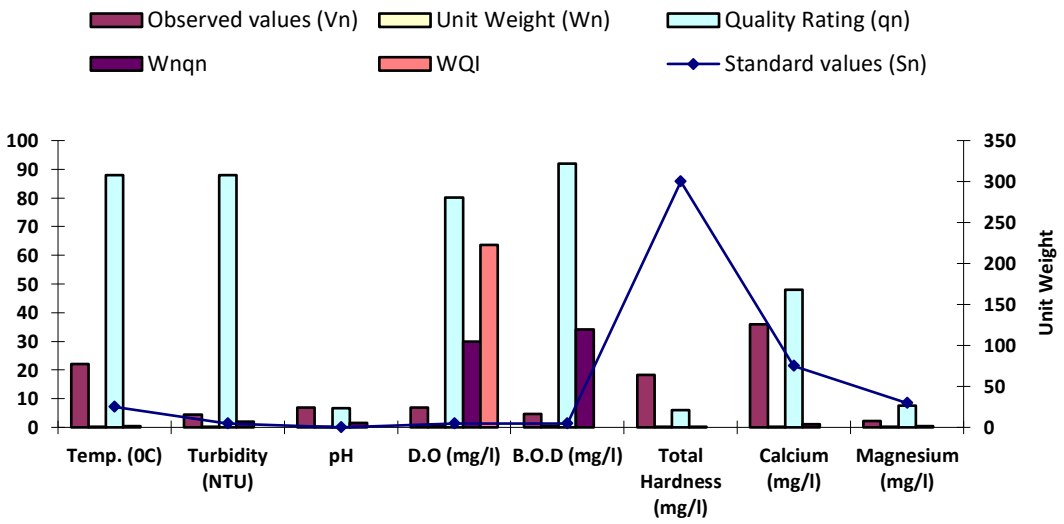

Fig. 4.2.16a: Calculation of WQI in Summer Season for Tube well water

Table 4.2.16b: Calculation of WQI in Winter Season for Tube well water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.6	25	0.00468	82.4	0.38	
Turbidity (NTU)	4.2	5	0.0234	84.0	1.96	
pH	7.0	6.5-8.5	0.2190	0	0	
D.O (mg/l)	6.9	5	0.3723	80.2	29.86	60.34
B.O.D (mg/l)	4.3	5	0.3723	86.0	32.01	
Total Hardness (mg/l)	12.5	300	0.0062	4.1	0.02	
Calcium (mg/l)	21.4	75	0.025	28.5	0.71	
Magnesium (mg/l)	2.1	30	0.061	7.0	0.42	
			$\sum W_n=1.083$		$\sum W_nq_n$ =65.39	

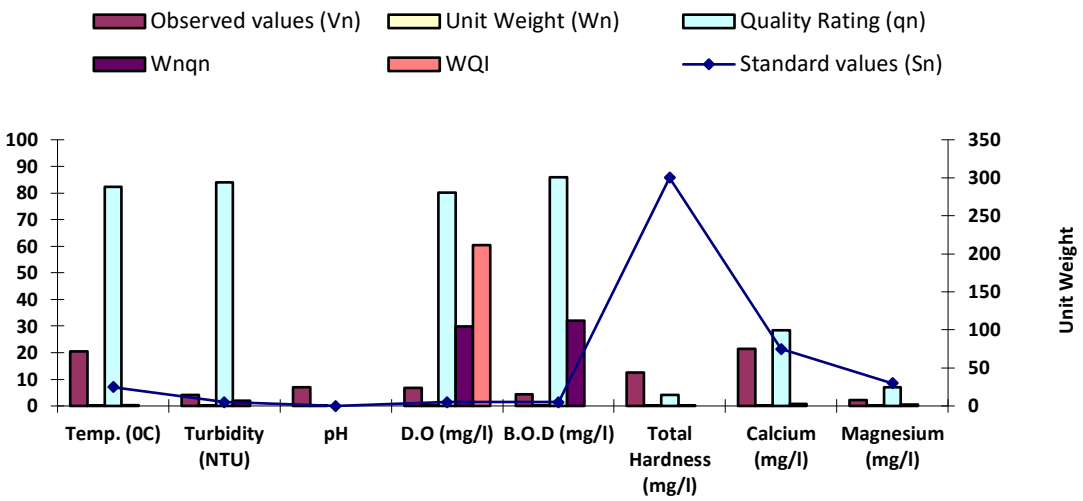

Fig. 4.2.16.b: Calculation of WQI in Winter Season for Tube well water

Table 4.2.16c: Calculation of WQI in Rainy Season for Tube well water

Parameters (Unit)	**Observed values (V_n)**	**Standard values (S_n)**	**Unit Weight (W_n)**	**Quality Rating (q_n)**	**W_nq_n**	**WQI**
Temp. (^{0}C)	23.5	25	0.00468	94.0	0.43	
Turbidity (NTU)	4.9	5	0.0234	98.0	2.29	
pH	6.5	6.5-8.5	0.2190	33.3	7.29	
D.O (mg/l)	6.7	5	0.3723	82.2	30.63	69.23
B.O.D (mg/l)	4.5	5	0.3723	90.0	33.50	
Total Hardness (mg/l)	13.6	300	0.0062	4.5	0.02	
Calcium (mg/l)	18.2	75	0.025	24.2	0.60	
Magnesium (mg/l)	1.1	30	0.061	3.6	0.22	
			$\sum W_n$=1.083		$\sum W_nq_n$ =75.03	

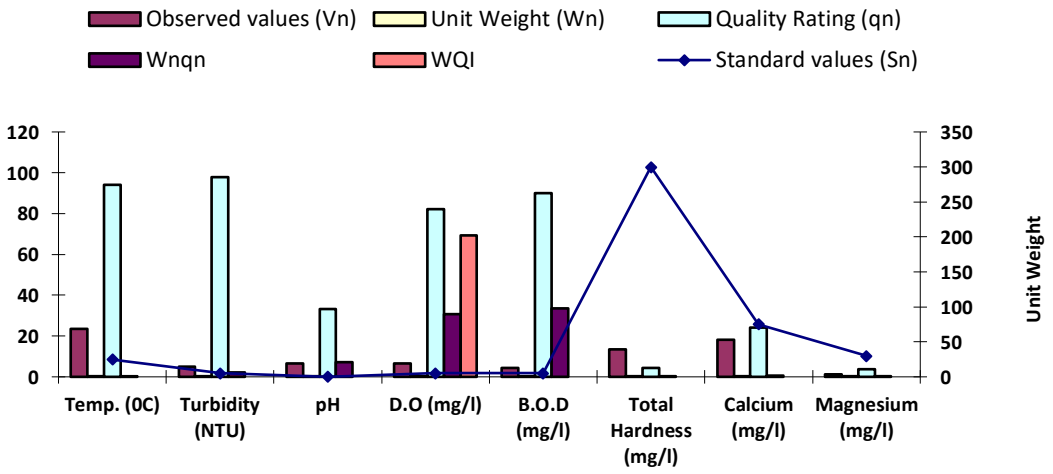

Fig. 4.2.16.c: Calculation of WQI in Rainy Season for Tube well water

Table 4.2.16.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Tube well water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The WQI was then calculated and compared to the classification of water quality based on weighted arithmetic WQI method. The WQI values observed 63.66, 60.34 and 69.23 during summer seasons, winter seasons and rainy seasons respectively. These values of WQI fall within 51-75 of the classification of water quality and is of poor quality. Thus, the present finding highlights the untreated water of tube well must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Akther and Tharani (2017); Maurya and Qureshi (2017); Amaaliya and Sugirtha (2013); Rajankar (2013).

Table 4.2.17a: Calculation of WQI in Summer Season for Spring water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.0	25	0.00468	44.0	0.20	
Turbidity (NTU)	10.0	5	0.0234	200.0	4.68	
pH	6.3	6.5-8.5	0.2190	46.6	10.22	
D.O (mg/l)	5.1	5	0.3723	98.9	36.84	89.77
B.O.D (mg/l)	6.0	5	0.3723	120.0	44.67	
Total Hardness (mg/l)	17.4	300	0.0062	5.8	0.03	
Calcium (mg/l)	11.9	75	0.025	15.8	0.39	
Magnesium (mg/l)	1.2	30	0.061	4.0	0.24	
			$\sum W_n$=1.083		$\sum W_nq_n$ =97.30	

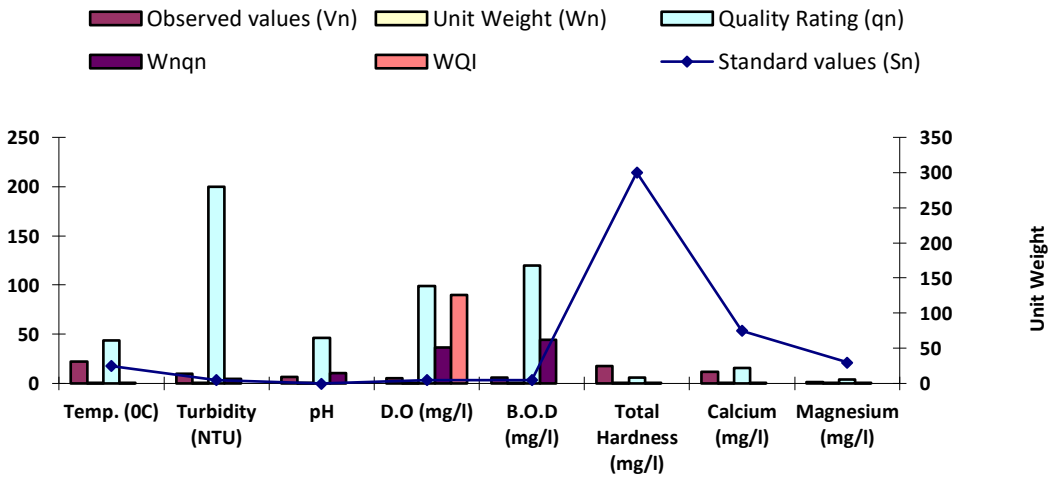

Fig. 4.2.17.a: Calculation of WQI in Summer Season for Spring water

Table 4.2.17b: Calculation of WQI in Winter Season for Spring water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	21.4	25	0.00468	85.6	0.40	
Turbidity (NTU)	8.5	5	0.0234	170.0	3.97	
pH	5.9	6.5-8.5	0.2190	73.3	16.05	
D.O (mg/l)	4.6	5	0.3723	104.1	38.78	94.49
B.O.D (mg/l)	5.7	5	0.3723	114.0	42.44	
Total Hardness (mg/l)	18.8	300	0.0062	6.2	0.03	
Calcium (mg/l)	11.6	75	0.025	15.4	0.38	
Magnesium (mg/l)	1.6	30	0.061	5.3	0.32	
			$\sum W_n$=1.083		$\sum W_nq_n$ =102.41	

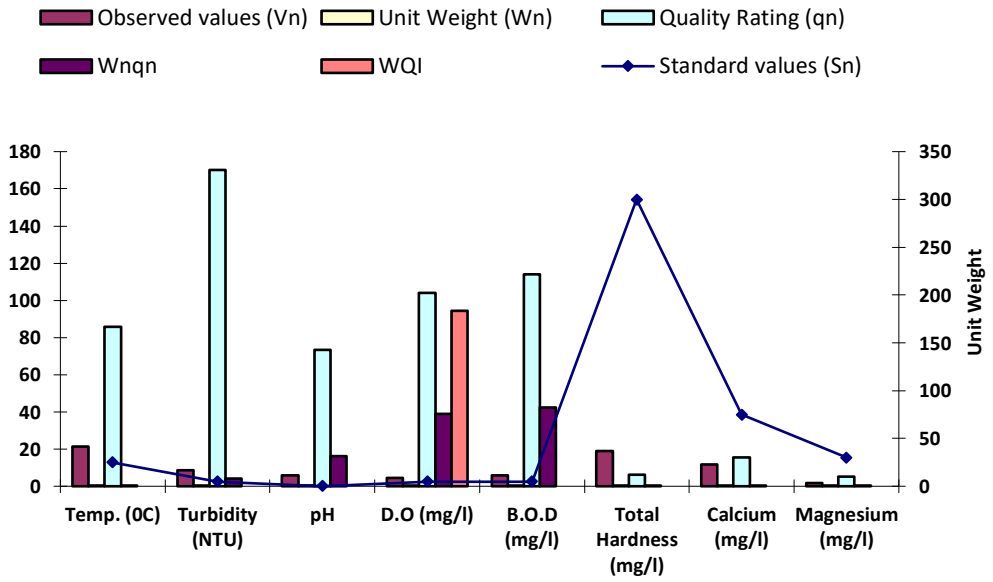

Fig. 4.2.17.b: Calculation of WQI in Winter Season for Spring water

Table 4.2.17c: Calculation of WQI in Rainy Season for Spring water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.9	25	0.00468	95.6	0.44	
Turbidity (NTU)	8.4	5	0.0234	168.0	3.93	
pH	5.7	6.5-8.5	0.2190	86.6	18.98	
D.O (mg/l)	4.7	5	0.3723	103.1	38.39	98.72
B.O.D (mg/l)	6.0	5	0.3723	120.0	44.67	
Total Hardness (mg/l)	16.9	300	0.0062	5.6	0.03	
Calcium (mg/l)	11.7	75	0.025	15.6	0.39	
Magnesium (mg/l)	1.2	30	0.061	4.0	0.24	
			$\sum W_n$=1.083		$\sum W_nq_n$ =107.09	

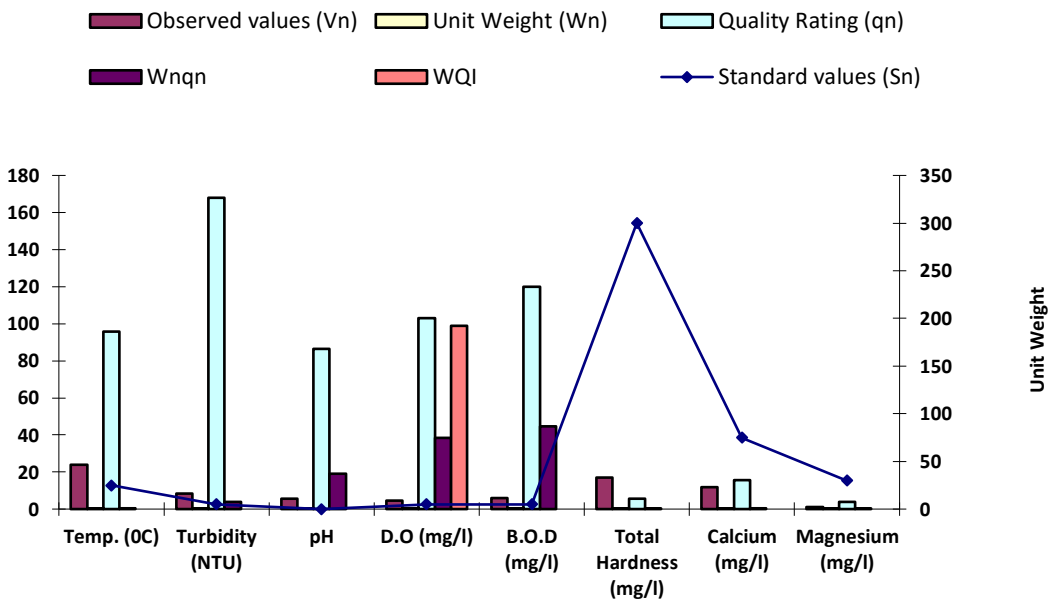

Fig. 4.2.17.c: Calculation of WQI in Rainy Season for Spring water

Table 4.2.17.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Spring water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The WQI was then calculated and compared to the classification of water quality based on weighted arithmetic WQI method. The WQI values observed 89.77, 94.49 and 69.298.123 during summer season, winter season and rainy season respectively. These values of WQI fall within 76-100 of the classification of water quality and are of very poor quality. Thus, the present finding highlights the untreated water of spring must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Akther and Tharani (2017); Maurya and Qureshi (2017); Amaaliya and Sugirtha (2013); Rajankar (2013).

Table 4.2.18a: Calculation of WQI in Summer Season for Maha River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.6	25	0.00468	94.4	0.44	
Turbidity (NTU)	40.0	5	0.0234	800.0	18.72	
pH	7.6	6.5-8.5	0.2190	40.0	8.76	
D.O (mg/l)	5.4	5	0.3723	95.8	35.67	98.85
B.O.D (mg/l)	5.3	5	0.3723	106.0	39.46	
Total Hardness (mg/l)	84.2	300	0.0062	28.0	0.17	
Calcium (mg/l)	18.9	75	0.025	25.2	0.63	
Magnesium (mg/l)	15.7	30	0.061	52.3	3.19	
			$\sum W_n=1.083$		$\sum W_nq_n$ =107.06	

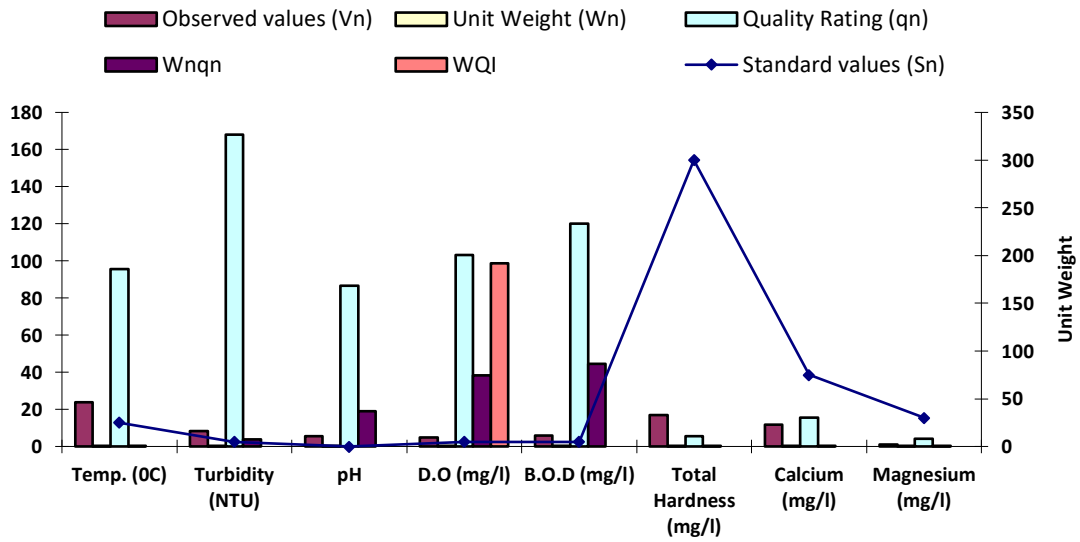

Fig. 4.2.18.a: Calculation of WQI in Summer Season for Maha River water

Table 4.2.18.b: Calculation of WQI in Winter Season for Maha River water

	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	16.5	25	0.00468	66.00	0.309	
Turbidity (NTU)	19.4	5	0.0234	388.00	9.079	
pH	7.4	6.5-8.5	0.2190	26.667	5.84	
D.O (mg/l)	5.1	5	0.3723	98.958	36.842	82.094
B.O.D (mg/l)	4.6	5	0.3723	92.00	34.252	
Total Hardness (mg/l)	56.6	300	0.0062	18.867	0.117	
Calcium (mg/l)	12.9	75	0.025	17.20	0.42	
Magnesium (mg/l)	10.4	30	0.061	34.667	2.115	
			$\sum W_n=1.083$		$\sum W_nq_n$ =88.974	

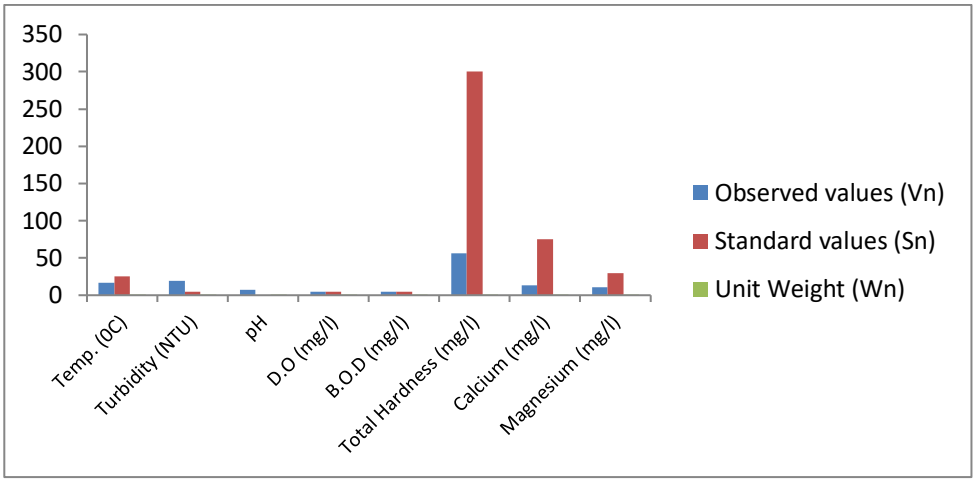

Fig. 4.2.18.b: Calculation of WQI in Winter Season for Maha River water

Table 4.2.18.c: Calculation of WQI in Rainy Season for Maha River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	24.9	25	0.00468	99.6	0.46	
Turbidity (NTU)	75.3	5	0.0234	1506.0	35.24	
pH	7.5	6.5-8.5	0.2190	33.3	7.29	
D.O (mg/l)	5.0	5	0.3723	100.0	37.23	108.28
B.O.D (mg/l)	4.6	5	0.3723	92.0	34.25	
Total Hardness (mg/l)	57.0	300	0.0062	19.0	0.11	
Calcium (mg/l)	12.6	75	0.025	16.8	0.42	
Magnesium (mg/l)	11.5	30	0.061	38.3	2.33	
			$\sum W_n$=1.083		$\sum W_nq_n$ =117.36	

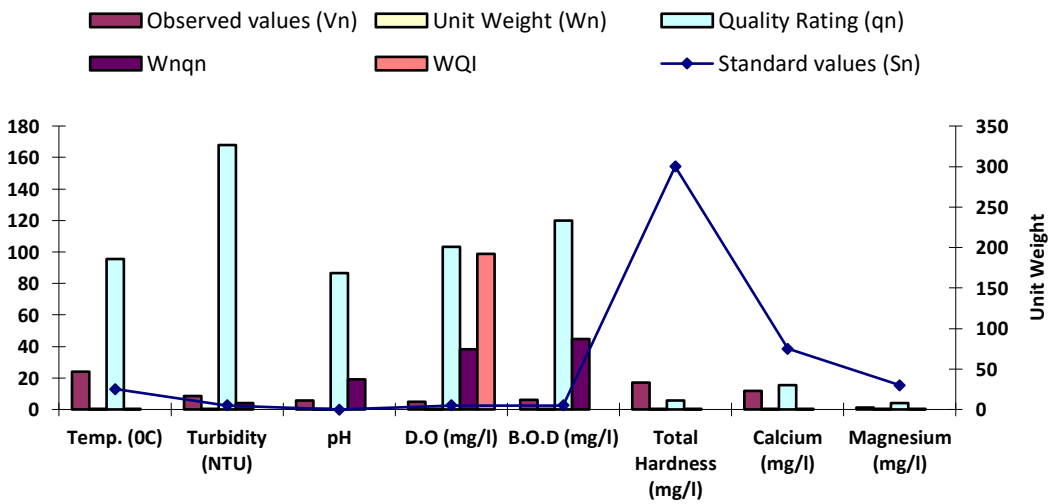

Fig. 4.2.18.c: Calculation of WQI in Rainy Season for Maha River water

Table 4.2.16.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Maha River water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The WQI was then calculated and compared to the classification of water quality based on weighted arithmetic WQI method. The WQI values observed 98.85, 82.094 and 108.28 during summer season, winter season and rainy season respectively. These values of WQI fall within 76.100 of the classification of water quality and is of very poor quality in summer and winter season and that of rainy season fall within above 100 of the classification of water quality and is of unsuitable for drinking. Thus, the present finding highlights the untreated water of Maha river must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Akther and Tharani (2017); Maurya and Qureshi (2017); Amaaliya and Sugirtha (2013); Rajankar (2013).

Table 4.2.19a: Calculation of WQI in Summer Season for Chakpi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.5	25	0.00468	94.0	0.43	
Turbidity (NTU)	39.7	5	0.0234	794.0	18.57	
pH	7.5	6.5-8.5	0.2190	33.3	7.29	
D.O (mg/l)	5.6	5	0.3723	93.7	34.90	96.88
B.O.D (mg/l)	5.4	5	0.3723	108.0	40.20	
Total Hardness (mg/l)	82.9	300	0.0062	27.6	0.17	
Calcium (mg/l)	18.9	75	0.025	25.2	0.63	
Magnesium (mg/l)	15.5	30	0.061	51.6	3.15	
			$\sum$Wn=1.083		$\sum W_nq_n$ =105.387	

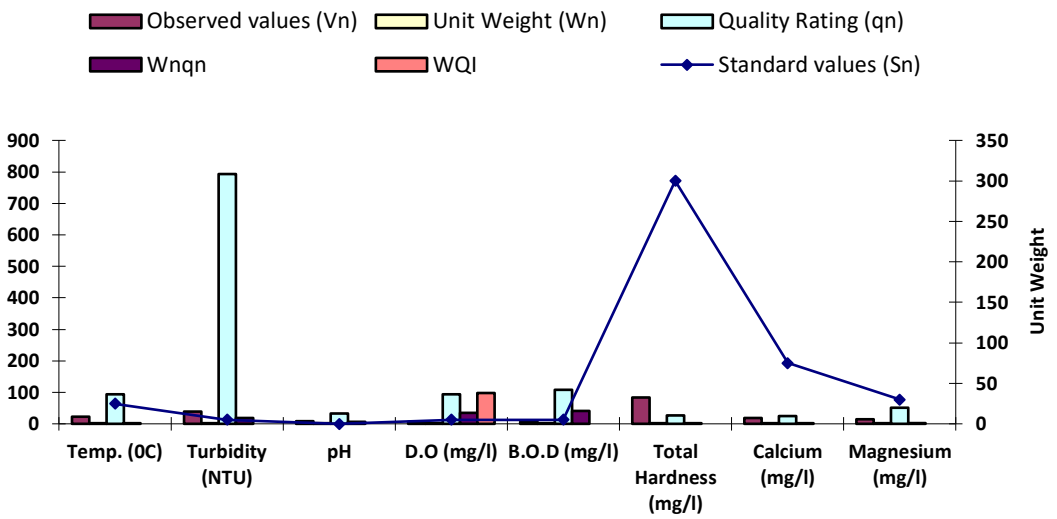

Fig. 4.2.19.a: Calculation of WQI in Summer Season for Chakpi River water

Table 4.2.19b: Calculation of WQI in Winter Season for Chakpi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.8	25	0.00468	83.2	0.38	
Turbidity (NTU)	20.1	5	0.0234	402.0	94.06	
pH	7.4	6.5-8.5	0.2190	26.6	5.84	
D.O (mg/l)	5.3	5	0.3723	96.8	36.06	161.20
B.O.D (mg/l)	4.8	5	0.3723	96.0	35.74	
Total Hardness (mg/l)	55.3	300	0.0062	18.4	0.11	
Calcium (mg/l)	13.2	75	0.025	17.6	0.44	
Magnesium (mg/l)	10.1	30	0.061	33.6	2.05	
			$\sum W_n$=1.083		$\sum W_nq_n$ =174.71	

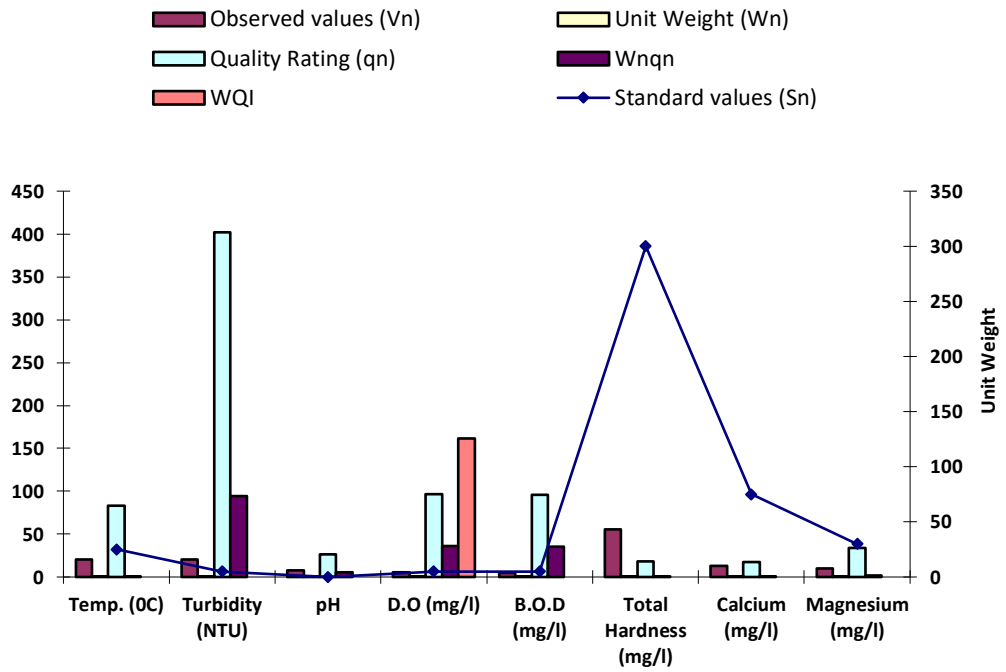

Fig. 4.2.19.b: Calculation of WQI in Winter Season for Chakpi River water

Table 4.2.19c: Calculation of WQI in Rainy Season for Chakpi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	25.0	25	0.00468	100.0	0.46	
Turbidity (NTU)	73.3	5	0.0234	1466.0	34.30	
pH	7.5	6.5-8.5	0.2190	33.3	7.29	
D.O (mg/l)	5.3	5	0.3723	96.8	36.06	107.27
B.O.D (mg/l)	4.7	5	0.3723	94.0	34.99	
Total Hardness (mg/l)	65.1	300	0.0062	21.7	0.13	
Calcium (mg/l)	13.0	75	0.025	17.3	0.43	
Magnesium (mg/l)	12.6	30	0.061	42.0	2.56	
			$\sum W_n$=1.083		$\sum W_nq_n$ =116.26	

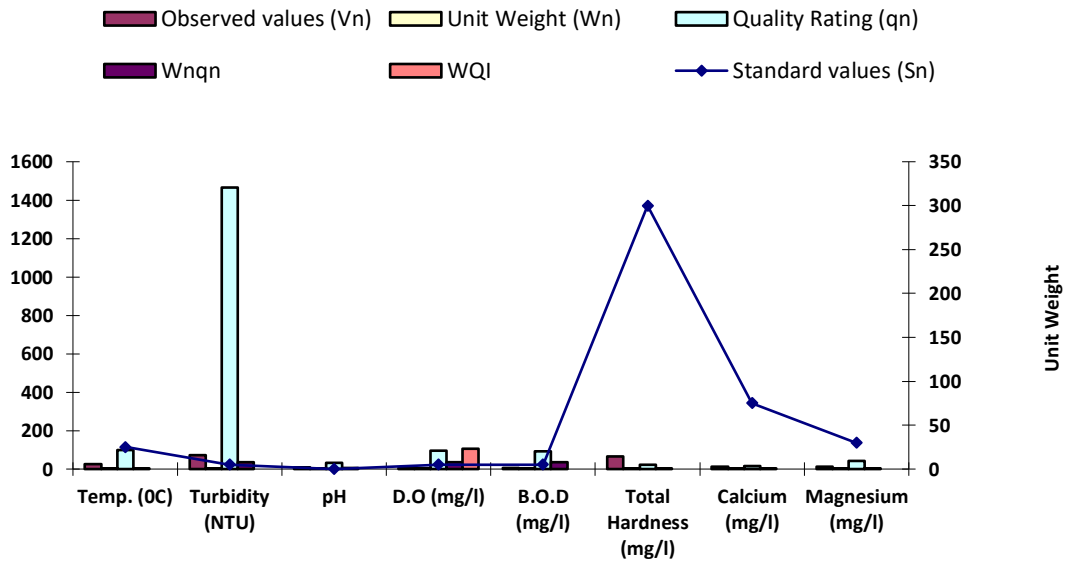

Fig. 4.2.19.c: Calculation of WQI in Rainy Season for Chakpi River water

Table 4.2.19.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Chakpi River water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The WQI was then calculated and compared to the classification of water quality based on weighted arithmetic WQI method. The WQI values observed 96.88, 161.20 and 107.27 during summer season, winter season and rainy season respectively. These values of WQI in summer season fall within 76-100 of the classification of water quality and is of very poor quality and the values of WQI with and rainy season fall within above 100 of the classification of WQI. Thus, the present finding highlights the untreated water of tubewell must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Awannavasa and Shrihari (2008); Maurya and Qureshi (2017); Amaaliya and Sugirtha (2013); Sk Oulididis (2009).

Table 4.2.20.a: Calculation of WQI in Summer Season for Machi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.9	25	0.00468	91.6	0.42	
Turbidity (NTU)	57.3	5	0.0234	1146.0	26.81	
pH	7.4	6.5-8.5	0.2190	26.6	5.84	
D.O (mg/l)	5.4	5	0.3723	95.8	35.6	104.22
B.O.D (mg/l)	5.4	5	0.3723	108.0	40.20	
Total Hardness (mg/l)	77.6	300	0.0062	25.8	0.16	
Calcium (mg/l)	17.8	75	0.025	23.7	0.59	
Magnesium (mg/l)	15.9	30	0.061	53.0	3.23	
			$\sum W_n$=1.083		$\sum W_nq_n$ =112.95	

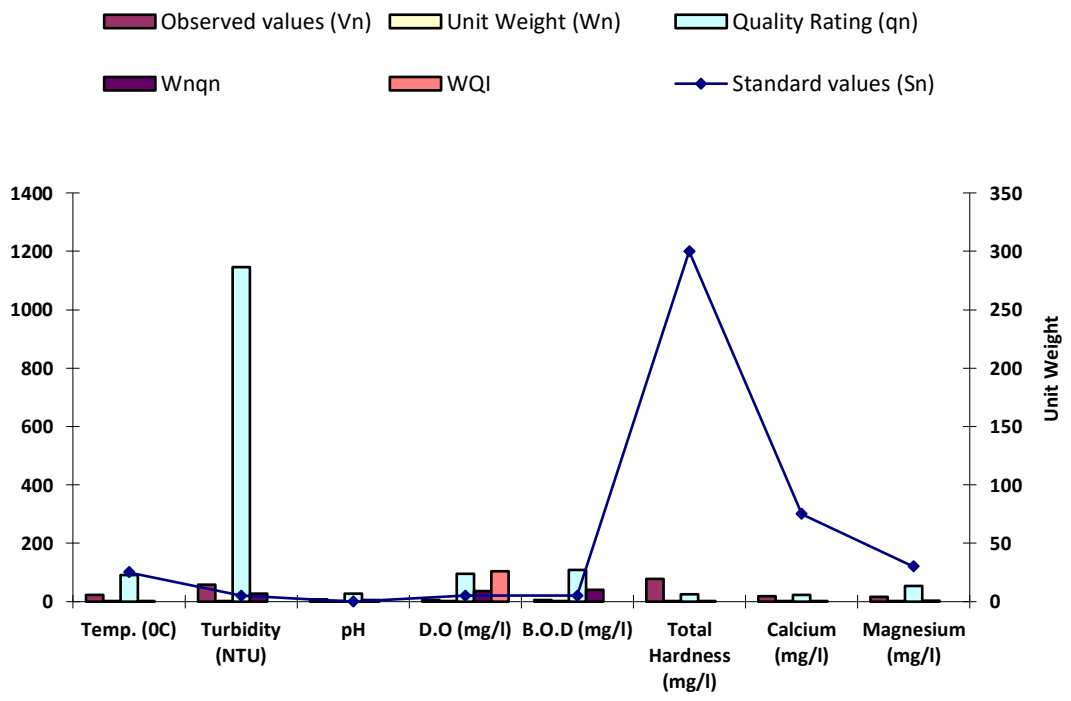

Fig. 4.2.19.a: Calculation of WQI in Summer Season for Machi River water

Table 4.2.20b: Calculation of WQI in Winter Season for Machi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.6	25	0.00468	82.4	0.38	
Turbidity (NTU)	20.8	5	0.0234	416.0	9.73	
pH	7.3	6.5-8.5	0.2190	20.0	7.44	
D.O (mg/l)	5.2	5	0.3723	97.9	36.45	84.53
B.O.D (mg/l)	4.7	5	0.3723	94.0	34.99	
Total Hardness (mg/l)	55.2	300	0.0062	18.4	0.11	
Calcium (mg/l)	13.2	75	0.025	17.6	0.44	
Magnesium (mg/l)	10.1	30	0.061	33.6	2.05	
			$\sum W_n=1.083$		$\sum W_nq_n$ =91.62	

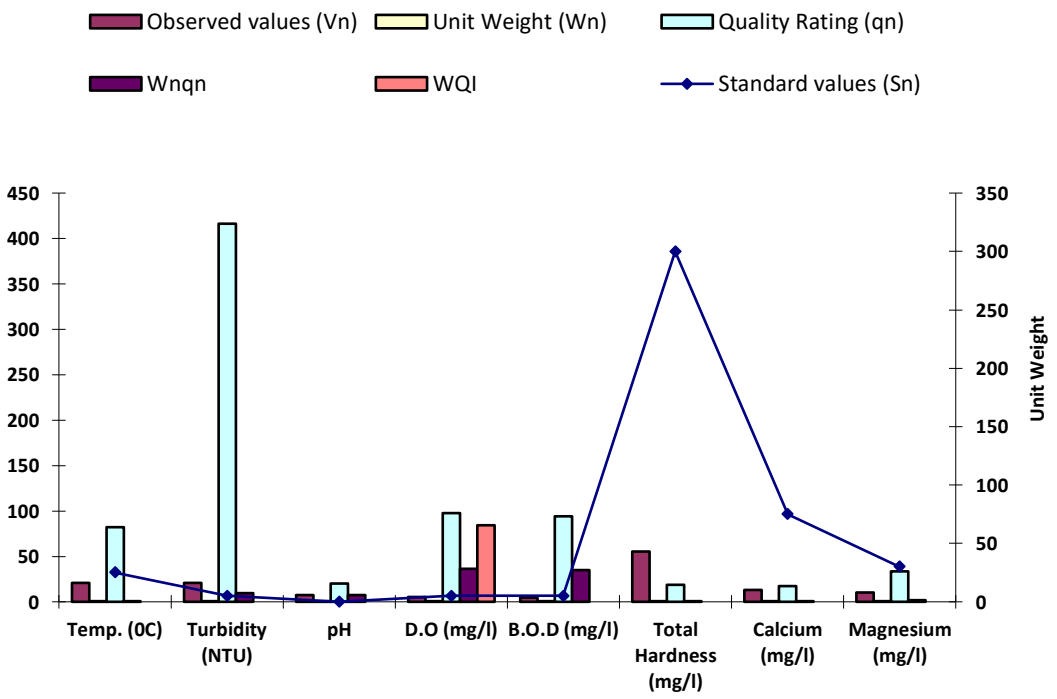

Fig. 4.2.19.b: Calculation of WQI in Winter Season for Machi River water

Table 4.2.20c: Calculation of WQI in Rainy Season for Machi River water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	24.8	25	0.00468	99.2	0.46	
Turbidity (NTU)	71.5	5	0.0234	1430.0	33.46	
pH	7.7	6.5-8.5	0.2190	46.6	10.22	
D.O (mg/l)	5.1	5	0.3723	98.9	36.84	107.43
B.O.D (mg/l)	4.4	5	0.3723	88.0	32.79	
Total Hardness (mg/l)	55.5	300	0.0062	18.5	0.11	
Calcium (mg/l)	10.7	75	0.025	14.2	0.35	
Magnesium (mg/l)	10.9	30	0.061	36.3	2.21	
			$\sum W_n=1.083$		$\sum W_nq_n$ =116.43	

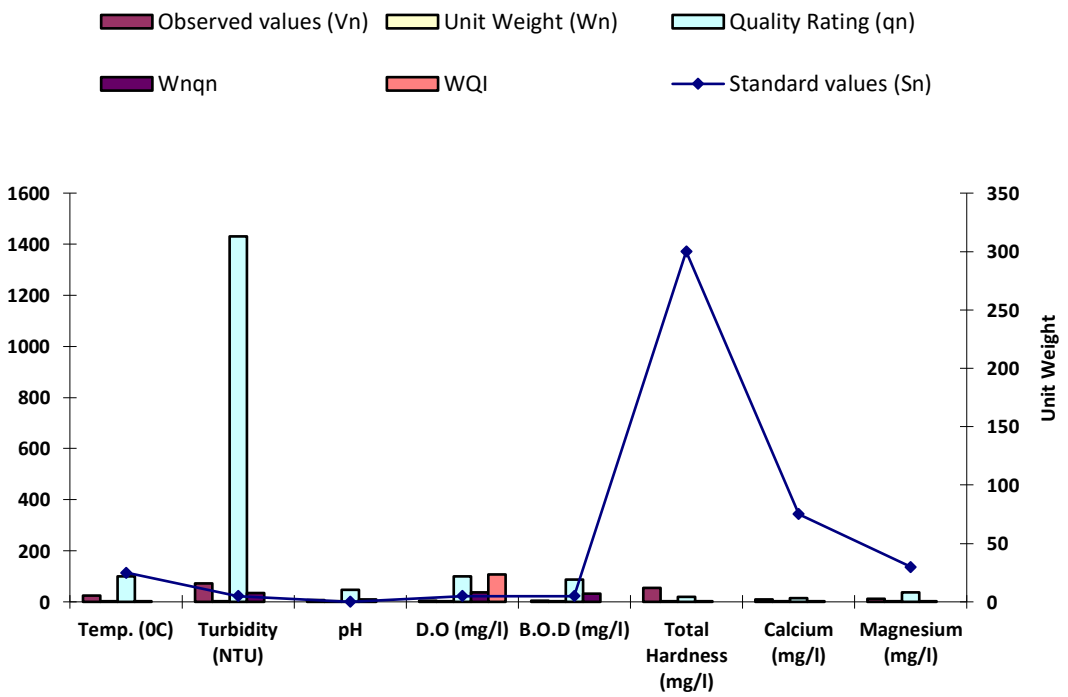

Fig. 4.2.19.c: Calculation of WQI in Rainy Season for Machi River water

Table 4.2.16.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Machi River water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The

WQI was then calculated and compared to the classification of water quality based on weighted arithmetic WQI method. The WQI values observed 104.22, 84.53 and 107.48 during summer seasons, winter seasons and rainy seasons respectively. These values of WQI in summer season for drinking fall within 100 above of the classification of water quality and is of unsuitable for drinking and the value pf WQI of winter season fall within 76-100 of the classification of water quality and it is of very poor quality. Thus, the present finding highlights the untreated water of Machi river must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Sivakumar *et.al.* (2011); Abowei (2010); Amaaliya and Sugirtha (2013); Sivamanikandan and John (2016).

Table 4.2.21a: Calculation of WQI in Summer Season for Pond water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	22.0	25	0.00468	88.0	0.41	
Turbidity (NTU)	7.8	5	0.0234	156.0	3.65	
pH	6.5	6.5-8.5	0.2190	33.3	7.29	
D.O (mg/l)	7.1	5	0.3723	78.1	29.08	99.09
B.O.D (mg/l)	8.9	5	0.3723	178.0	66.26	
Total Hardness (mg/l)	14.0	300	0.0062	4.667	0.02	
Calcium (mg/l)	15.4	75	0.025	20.5	0.51	
Magnesium (mg/l)	0.7	30	0.061	2.3	0.14	
			$\sum W_n=1.083$		$\sum W_nq_n=107.40$	

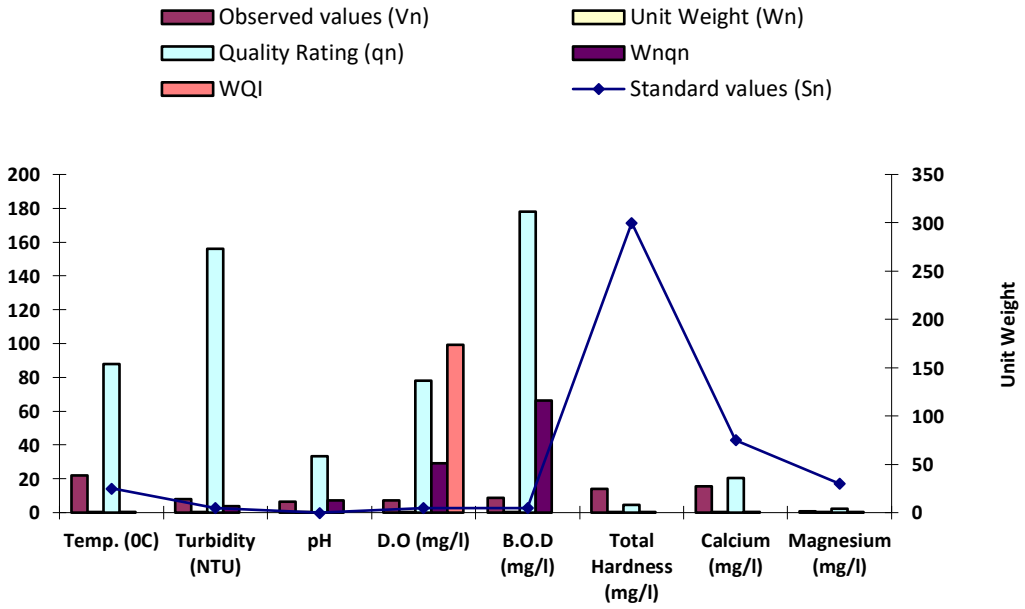

Fig. 4.2.21.a: Calculation of WQI in Summer Season for Pond water

Table 4.2.21b: Calculation of WQI in Winter Season for Pond water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	20.5	25	0.00468	82.0	0.38	
Turbidity (NTU)	6.9	5	0.0234	138.0	3.22	
pH	7.0	6.5-8.5	0.2190	0	0	
D.O (mg/l)	7.6	5	0.3723	72.91	27.14	89.43
B.O.D (mg/l)	8.8	5	0.3723	176.0	65.5	
Total Hardness (mg/l)	12.3	300	0.0062	4.1	0.02	
Calcium (mg/l)	12.5	75	0.025	16.6	0.47	
Magnesium (mg/l)	1.0	30	0.061	3.3	0.20	
			$\sum W_n$=1.083		$\sum W_nq_n$ =96.93	

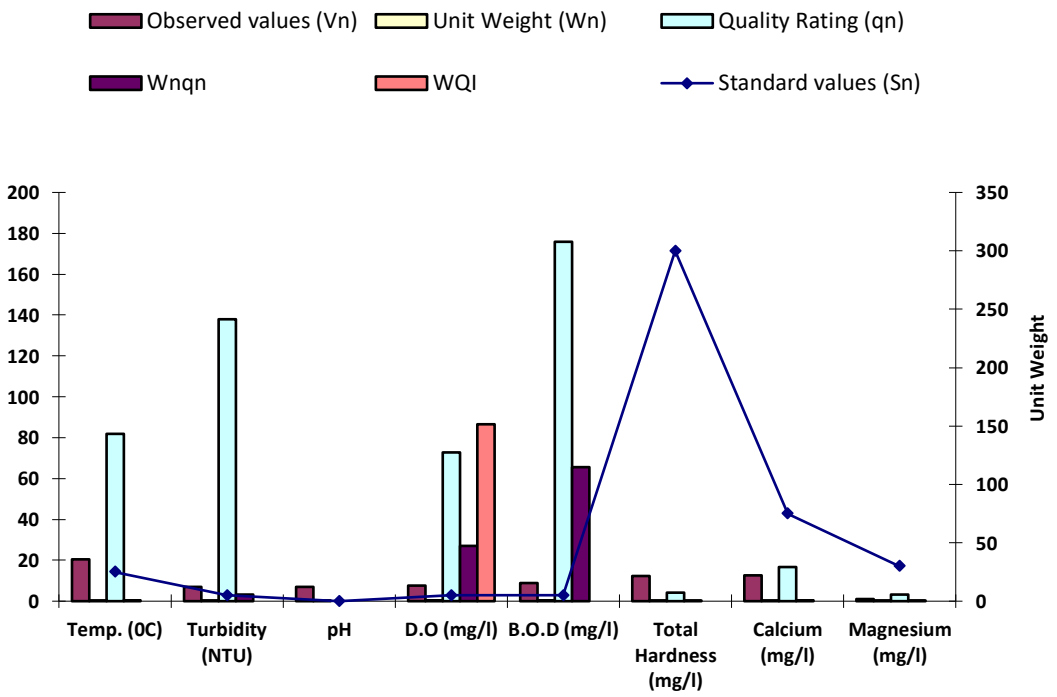

Fig. 4.2.19.b: Calculation of WQI in Winter Season for Pond water

Table 4.2.21c: Calculation of WQI in Rainy Season for Pond water

Parameters (Unit)	Observed values (V_n)	Standard values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n	WQI
Temp. (^{0}C)	23.5	25	0.00468	94.0	0.43	
Turbidity (NTU)	7.9	5	0.0234	158.0	36.9	
pH	6.7	6.5-8.5	0.2190	20.0	4.3	
D.O (mg/l)	6.0	5	0.3723	89.5	33.3	130.35
B.O.D (mg/l)	8.7	5	0.3723	174.0	64.7	
Total Hardness (mg/l)	11.2	300	0.0062	3.7	0.02	
Calcium (mg/l)	23.0	75	0.025	30.6	0.76	
Magnesium (mg/l)	2.8	30	0.061	9.3	0.56	
			∑Wn=1.083		∑ W_nq_n =141.28	

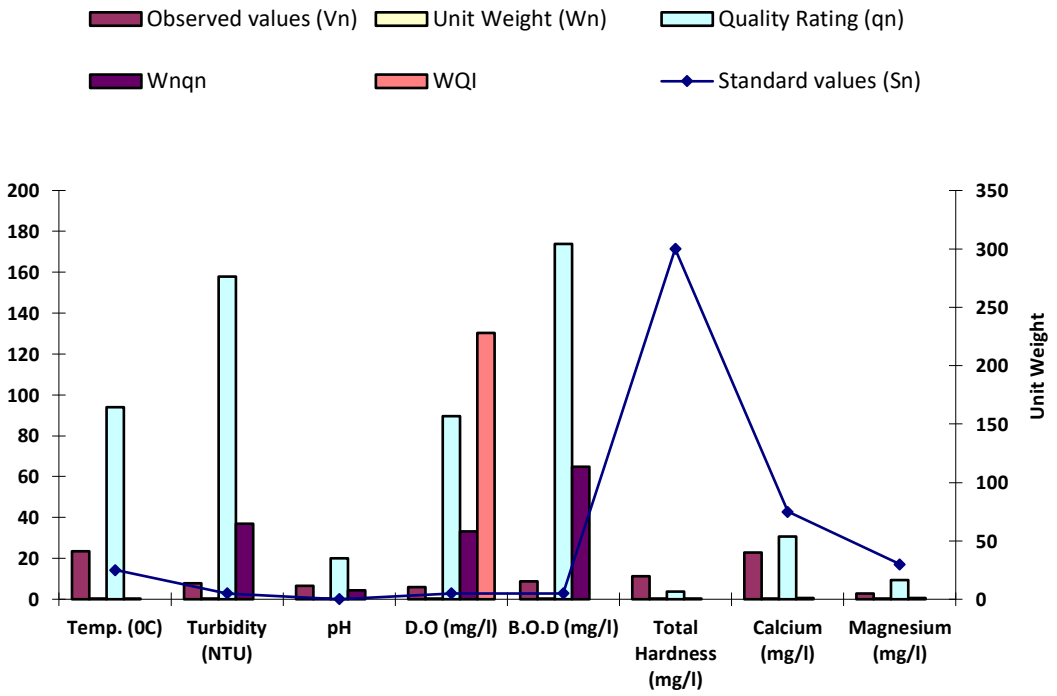

Fig. 4.2.19.c: Calculation of WQI in Rainy Season for Pond water

Table 4.2.16.a, b and c highlighted the observed values (V_n) of the eight (8) selected physic-chemical parameters of the Pond Water samples collected during October 2015 to September 2018, standard drinking water values (S_n) according to WHO, 2013; BIS, 2012, Unit weight (W_n), water quality rating (q_n) and W_nq_n. The WQI was then calculated and compared to the classification of water quality based on

weighted arithmetic WQI method. The WQI values observed 99.09, 89.49 and 130.35 during summer season, winter season and rainy season respectively. These values of WQI in summer and winter season fall within 76-100 of the classification of water quality and is of very poor quality. The WQI in rainy season fall within above 100 of the classification of water quality and is of unsuitable for drinking water. Thus, the present finding highlights the untreated water of tubewell must require treated with proper water quality treatment method before use. The present investigation was in concordance with the work of Akther and Tharani (2017); Maurya and Qureshi (2017); Amaaliya and Sugirtha (2013); Rajankar (2013).

4.3. INVESTIGATION ON EXPLOITATION OF NATURAL SOIL AND LAND RESOURCES OF CHANDEL DISTRICT, MANIPUR

During the investigation period from 1stNovember 2015 to 30th October 2016, twenty (20) observations under rainy days were selected for experimentation level of rainfall, rainfall intensities, kinetic energy (K.E.) and erosion index (K.I). The rainfall in 30 min observed with a range between 13.4mm to 53.6mm. The rain intensity in cm/hr was observed 3.2cm/hr as the highest intensity and 0.6cm/hr as the lowest intensity. Likewise, the rain intensity in mm/hr was in the range between 6.7mm/hr to 32.6mm/hr. The Kinetic energy (K.E) of each rainfall intensity was calculated with a range between 283.82Mt ha^{-1} to 344.97Mt ha^{-1}. The erosion index (KI) scored highest with a value of 1103.90Mt ha^{-1}cm^{-1} and lowest n170.29Mt ha^{-1}. The observed and computed values of different soil erosion factors has tabulated in Table 4.3.1 and graphically represented in Fig.4. 3.1.

Table 4.3.1 Rain intensity, Erosion index (K.I) and Kinetic energy (K.E) of rainfall data on 20 observations during Nov. 2015 to Oct., 2016 at Chandel

Sl. No.	Date	Rainfall in 30 min*	Intensity		K.E. *Ht^{-1}	Ki* Mt ha $^{-1}$ cm^{-1} (x10^{-2})
			cm/hr	mm/hr		
1.	17-4-16	24.0	1.2	12.00	306.34	367.60
2.	23-4-16	26.0	1.3	13.00	309.44	402.27
3.	01-5-16	32.0	1.6	16.00	317.51	508.01
4.	10-6-16	34.0	1.7	17.00	319.80	543.66
5.	23-7-16	36.8	1.8	18.4	322.86	581.14
6.	24-7-16	65.2	3.2	32.6	344.97	1103.90
7.	25-7-16	53.6	2.6	26.8	337.40	877.24

8.	27-7-16	13.4	0.6	06.7	283.82	170.29
9.	02-8-16	38.8	1.9	19.4	324.91	617.32
10.	06-8-16	20.4	1.0	10.2	3…06	300.06
11.	16-8-16	30.4	1.5	12.2	315.48	476.22
12.	21-8-16	42.8	2.1	21.4	328.70	690.27
13.	22-8-16	37.6	1.8	18.8	329.77	582.66
14.	31-8-16	44.0	2.2	22.0	297.72	725.49
15.	01-9-16	19.2	0.9	09.6	314.97	267.94
16.	06-9-16	30.0	1.5	15.0	335.93	472.45
17.	20-9-16	51.6	2.5	25.8	310.61	839.82
18.	21-9-16	26.8	1.3	13.4	321.58	403.79
19.	10-10-16	35.6	1.7	17.8	298.12	546.68
20.	25-10-16	19.4	0.9	09.7		268.30

*Significant at 0.05level

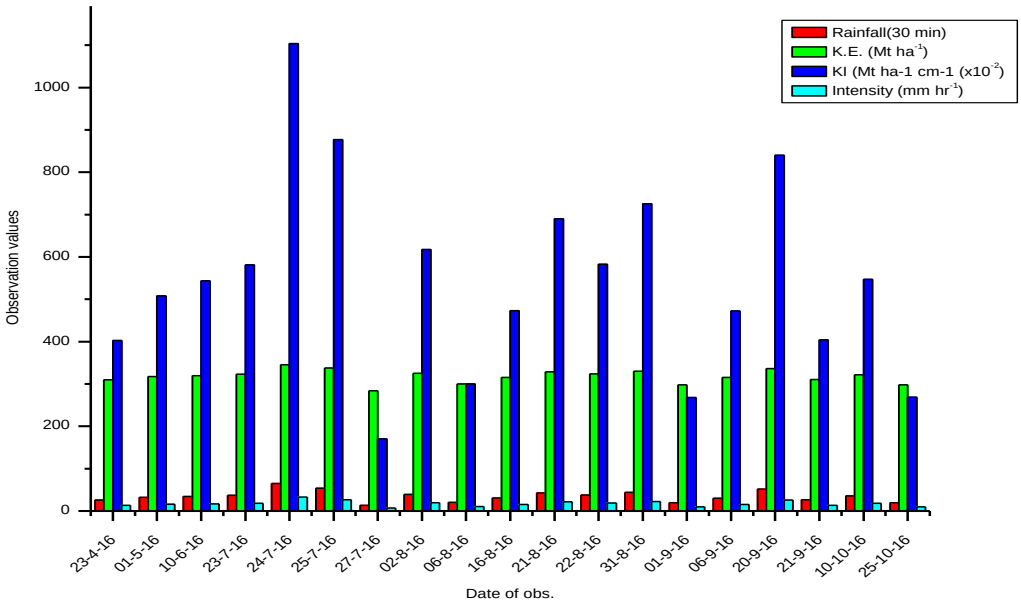

Fig. 4.3.1: Rain intensity, Erosion index (K.I) and Kinetic energy (K.E) of rainfall data on 20 observations during Nov. 2015 to Oct. 2016 at Chandel

Table 4.3.1 highlighted twenty (20) observations under rainy days were selected for experimentation level of rainfall, rainfall intensities, kinetic energy (K.E.) and erosion index (K.I). The rainfall in 30 min observed with a range between 13.4mm to 53.6mm. The rain intensity in cm/hr was observed 3.2cm/hr as the highest intensity and 0.6cm/hr as the lowest intensity. Likewise, the rain intensity in mm/hr was in the range between 6.7mm/hr to 32.6mm/hr. The Kinetic energy (K.E) of each rainfall intensity was calculated with a range between 283.82Mt ha^{-1} to 344.97Mt ha^{-1}. The erosion

index (KI) scored highest with a value of 1103.90Mt $ha^{-1}cm^{-1}$ and lowest n170.29Mt ha^{-1}.

The runoff in red and dark soils with effect of different slope length at 2% slope gradient was observed from rain intensity and calculated by using dimensionless coefficient, C=0.20 for red soil and C=0.30 for dark soil. The catchment area, A of 20ft was 3.72 x 10^{-4}hectares, 7.43 x 10^{-4}hectares for 40 ft and 1.12 x10^{-3} hectares for 60ft. For red soil of 20ft length, the runoff, Q was in the range between 1.38 x10^{-6} m^3 sec^{-1} (I=6.7mm/hr) to 6.73 x $10^{-6}$$sec^{-1}$ (1=32.6mm/hr). In case of 40ft length, the runoff, Q was in the range between 2.76 x 10-$^{-1}$$m^3$ $see^{-1}$to 13.45 x $10^{-6}$$m^3$ sec^{-1} and for 60ft, the runoff was in between 4.16 x $10^{-6}$$m^3$ sec^{-1} to 20.28x $10^{-6}$$m^3$ sec^{-1}. For dark soil of 20 ft length, the runoff, Q was observed highest at the intensity of rain 32.6mm.hr (2.07 x$10^{-6}$$m^3$ sec^{-1}) and lowest at the intensity of 6.7mm/hr (10.10 x$10^{-6}$$m^3$ sec^{-1}). Incase of 40 ft length, the runoff, Q was observed with a range between 4.14 x$10^{-6}$$m^3$ $sec^{-1}$to 20.18 x$10^{-6}$$m^3$ $sec^{-1}$and for 60 ft length, it was between 6.25 x$10^{-6}$$m^3$ $sec^{-1}$to 30.42 x$10^{-6}$$m^3$ sec^{-1}. The observed and calculated values were displayed in Table 4.3.2 and graphically represented in Fig 4.3.2a & b.

Table 4.3.2: Effect of slope length on the rate of runoff in types of soil

Sl. No.	Date	Intensity I mm/hr	Red Soil Runoff m^3/sec			Dark soil Runoff m^3/sec		
			20ft	40ft	60ft	20ft	40ft	60ft
1.	17-4-16	12.0	2.48 x10^{-6}	4.95 x10^{-6}	7.46 x10^{-6}	3.72 x10^{-6}	7.43 x10^{-6}	11.20 x10^{-6}
2.	23-4-16	13.0	2.70 x10^{-6}	5.36 x10^{-6}	8.08 x10^{-6}	4.03 x10^{-6}	8.04 x10^{-6}	12.13 x10^{-6}
3.	01-5-16	16.02	3.31 x10^{-6}	6.61 x10^{-6}	9.96 x10^{-6}	5.02 x10^{-6}	9.99 x10^{-6}	14. 95 x10^{-6}
4.	10-5-16	17.0	3.51 x10^{-6}	7.0 x10^{-6}1	10.57 x10^{-6}	5.27 x10^{-6}	10.52 x10^{-6}	15.86 x10^{-6}
5.	23-7-16	18.4	3.80 x10^{-6}	7.59 x10^{-6}	11.44 x10^{-6}	5.70 x10^{-6}	11.39 x10^{-6}	17.17 x10^{-6}
6.	24-7-16	32.6	6.73 x10^{-6}	13.45 x10^{-6}	20.28 x10^{-6}	10.10 x10^{-6}	20.18 x10^{-6}	30.42 x10^{-6}
7.	25-7-16	26.8	5.53 x10^{-6}	11.06 x10^{-6}	16.68 x10^{-6}	8.30 x10^{-6}	16.59 x10^{-6}	25.01 x10^{-6}
8.	27-7-16	6.7	1.38 x10^{-6}	2.76 x10^{-6}	4.16 x10^{-6}	2.07 x10^{-6}	4.14 x10^{-6}	6.25 x10^{-6}
9.	02-8-16	19.4	4.0 x10^{-6}	8.0 x10^{-6}	12.07 x10^{-6}	6.01 x10^{-6}	12.01 x10^{-6}	18.10 x10^{-6}
10.	06-8-16	10.2	2.10 x10^{-6}	4.2 x10^{-6}	6.34 x10^{-6}	3.16 x10^{-6}	6.31 x10^{-6}	9.52 x10^{-6}
11.	16-8-16	15.2	3.14 x10^{-6}	6.27 x10^{-6}	9.45 x10^{-6}	4.71 x10^{-6}	9.41 x10^{-6}	14.18 x10^{-6}
12.	21-8-16	21.4	4.42 x10^{-6}	8.83 x10^{-6}	13.31 x10^{-6}	6.63 x10^{-6}	13.25 x10^{-6}	19.97 x10^{-6}
13.	22-8-16	18.8	3.88 x10^{-6}	7.76 x10^{-6}	11.69 x10^{-6}	5.82 x10^{-6}	11.64 x10^{-6}	17.54 x10^{-6}
14.	31-8-16	22.0	4.54 x10^{-6}	9.08 x10^{-6}	13.68 x10^{-6}	6.82 x10^{-6}	13.62 x10^{-6}	20.53 x10^{-6}
15.	01-9-16	9.6	1.98 x10^{-6}	3.96 x10^{-6}	5.97 x10^{-6}	2.97 x10^{-6}	5.94 x10^{-6}	8.96 x10^{-6}
16.	06-9-16	15.0	3.1 x10^{-6}	6.19 x10^{-6}	9.33 x10^{-6}	4.65 x10^{-6}	9.28 x10^{-6}	14.0 x10^{-6}
17.	20-9-16	25.8	5.33 x10^{-6}	10.64 x10^{-6}	16.05 x10^{-6}	7.99 x10^{-6}	15.97 x10^{-6}	24.08 x10^{-6}
18.	21-9-16	13.4	2.76 x10^{-6}	5.53 x10^{-6}	8.33 x10^{-6}	4.15 x10^{-6}	8.29 x10^{-6}	12.50 x10^{-6}
19.	10-10-16	17.8	3.67 x10^{-6}	7.34 x10^{-6}	11.07 x10^{-6}	5.51 x10^{-6}	11.02 x10^{-6}	16.61 x10^{-6}
20.	25-10-16	9.7	2.0 x10^{-6}	4.0 x10^{-6}	6.03 x10^{-6}	3.0 x10^{-6}	6.0 x10^{-6}	9.05 x10^{-6}

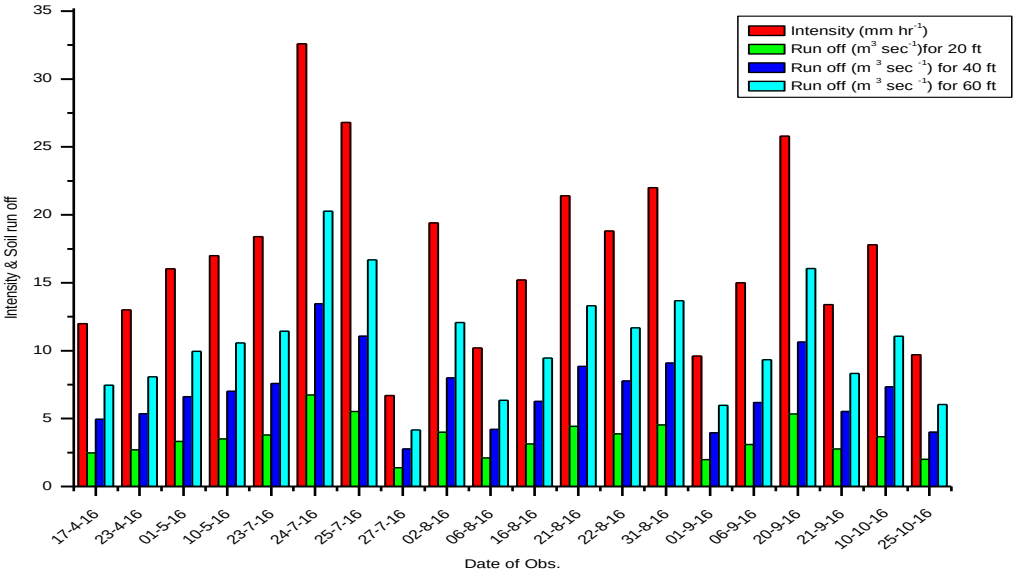

Fig. 4.3.2a: Effect of slope length on the rate of runoff in red soil

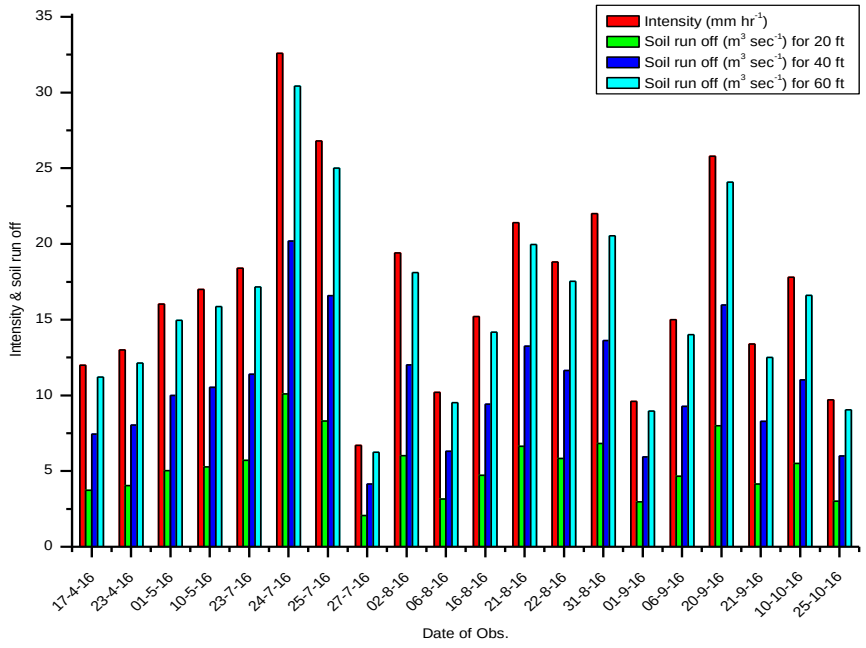

Fig. 4.3.2.b: Effect of slope length on the rate of runoff in dark soil

Table 4.3.2 displayed the runoff in red and dark soils with effect of different slope length at 2% slope gradient was observed from rain intensity and calculated by

using dimensionless coefficient, C=0.20 for red soil and C=0.30 for dark soil. The catchment area, A of 20ft was 3.72 x 10^{-4}hectares, 7.43 x 10^{-4}hectares for 40 ft and 1.12 x10^{-3} hectares for 60ft. For red soil of 20ft length, the runoff, Q was in the range between 1.38 x10^{-6} m^3 sec^{-1} (I=6.7mm/hr) to 6.73 x $10^{-6}$$sec^{-1}$ (1=32.6mm/hr). In case of 40ft length, the runoff, Q was in the range between 2.76 x 10-^{1}m^3 see^{-1}to 13.45 x $10^{-6}$$m^3$ sec^{-1} and for 60ft, the runoff was in between 4.16 x $10^{-6}$$m^3$ sec^{-1} to 20.28x $10^{-6}$$m^3$ sec^{-1}. For dark soil of 20 ft length, the runoff, Q was observed highest at the intensity of rain 32.6mm.hr (2.07 x$10^{-6}$$m^3$ sec^{-1}) and lowest at the intensity of 6.7mm/hr (10.10 x$10^{-6}$$m^3$ sec^{-1}). In case of 40 ft length, the runoff, Q was observed with a range between 4.14 x$10^{-6}$$m^3$ $sec^{-1}$to 20.18 x$10^{-6}$$m^3$ sec^{-1} and for 60 ft length, it was between 6.25 x$10^{-6}$$m^3$ $sec^{-1}$to 30.42 x$10^{-6}$$m^3$ sec^{-1}.

During the investigation period November 2015 to October 2016 at Chandel district observed highest rainfall intensity on 24th July 2016 with 32.6mm/hr and least rainfall intensity 6.7mm/hr on 27th July 2016. For red soil, the soil loss of 0.01% slope was observed with a range of 3.69 t $ha^{-l}yr^{-1}$ to 21.70 t $ha^{-1}yr^{-1}$; 2% slope soil loss was in the range between 09.15 t $ha^{-l}yr^{-1}$ to 42.56 t $ha^{-l}yr^{-1}$; for 3% slope it was in between 15.98 t $ha^{-l}yr^{-1}$ to 56.81 t $ha^{-l}yr^{-1}$ and for 5% slope the soil loss was observed in the range between 31.97 t $ha^{-1}yr^{-1}$ to 91.11 t $ha^{-l}yr^{-1}$. Incase of dark soil for 0.017 slope the soil loss was scored highest 29.68 t $ha^{-l}yr^{-1}$ on 24th July 2016 with an intensity of 32.6mm/hr and lest 5.97 t $ha^{-1}yr^{-1}$ on 27th July 2016 with an intensity of 6.7mm.hr. For 2% slope, the soil loss accounts highest 58.03 t $ha^{1}yr^{-1}$ with the rainfall intensity of 32.6mm.hr and least 18.57 t $ha^{-l}yr^{-I}$ with the intensity of 9.6mm.hr and for 3% slope, the soil loss was observed highest 77.55 t $ha^{-l}yr^{-1}$ with the rainfall intensity of 32.6mm/yr and least 25.54 t $ha^{-l}yr^{-1}$ with the intensity of 9.6mm/hr. Regarding 5% slope the soil loss was observed in range between 42.80 t $ha^{-1}yr^{-1}$ to 124.01 t $ha^{-l}yr^{-1}$. The observed data on impact of different slope steepness on soil loss at 40ft slope lengths were displayed in Table 4.3.3 and graphically portrayed in Fig. 4.3.3a & b.

Table 4.3.3a: Impact of different slope steepness on soil loss at 40 ft slope length during November 2015 to October 2016 at Chandel

Sl. No.	Date	Intensity (mm/hr)	Soil loss (t ha-1 yr-1) in Red soil					0.02%	3%	5%
			0.01%	2%	3%	5%	0.01%			
1.	17-4-16	12.0	0.7.17	12.55	19.68	35.37	9.66	20.07	27.04	46.30
2.	23-4-16	13.0	7.42	14.58	19.77	35.67	10.28	21.17	28.60	47.60
3.	01-5-16	16.02	9.92	20.21	27.27	43.07	13.29	27.99	38.25	61.05
4.	10-6-16	17.0	10.30	20.75	27.87	43.58	13.89	28.51	38.75	61.65
5.	23-7-16	18.4	10.96	21.38	28.55	44.23	14.53	29.14	38.91	62.31
6.	24-7-16	32.6	21.70	42.56	56.81	91.11	29.68	58.03	77.55	124.01
7.	25-7-16	26.8	17.26	33.75	45.09	72.24	23.55	46.02	61.49	98.50
8.	27-7-16	6.7	3.96	9.15	15.98	31.97	5.97	44.47	23.44	42.80
9.	02-8-16	19.4	11.45	21.97	29.14	44.84	15.12	29.76	39.51	62.91
10.	06-8-16	10.2	0.18	11.57	28.50	34.49	8.58	18.99	25.95	45.29
11.	16-8-16	15.2	9.30	19.63	26.74	42.44	12.66	27.87	38.22	60.51
12.	21-8-16	21.4	18.23	33.56	44.25	69.55	24.37	45.47	38.36	62.24
13.	22-8-16	18.8	10.99	21.71	28.59	44.98	14.89	29.89	39.06	62.94
14.	31-8-16	22.0	18.93	34.26	44.97	70.25	25.07	46.17	60.30	95.84
15.	01-9-16	9.6	5.77	1115	18.08	34.07	8.15	18.57	25.54	44.90
16.	06-9-16	15.0	9.23	19.56	26.67	42.37	12.59	27.79	38.15	60.45
17.	20-9-16	25.8	16.83	32.16	42.87	68.15	22.92	44.93	58.10	93.64
18.	21-9-16	13.4	7.89	14.79	19.91	31.98	10.83	28.55	38.25	61.69
19.	10-10-16	17.8	10.48	20.91	28.05	43.76	14.07	28.69	38.43	61.83
20.	25-10-16	9.7	5.83	11.22	18.15	34.14	8.23	18.64	25.60	44.96

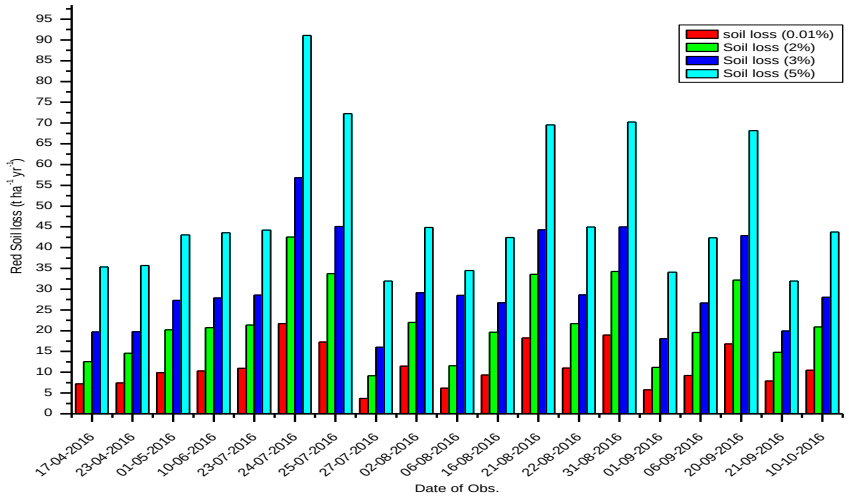

Fig. 4.3.3a: Impact of different slope steepness on red soil loss at 40 ft slope length during November 2015 to October 2016 at Chandel

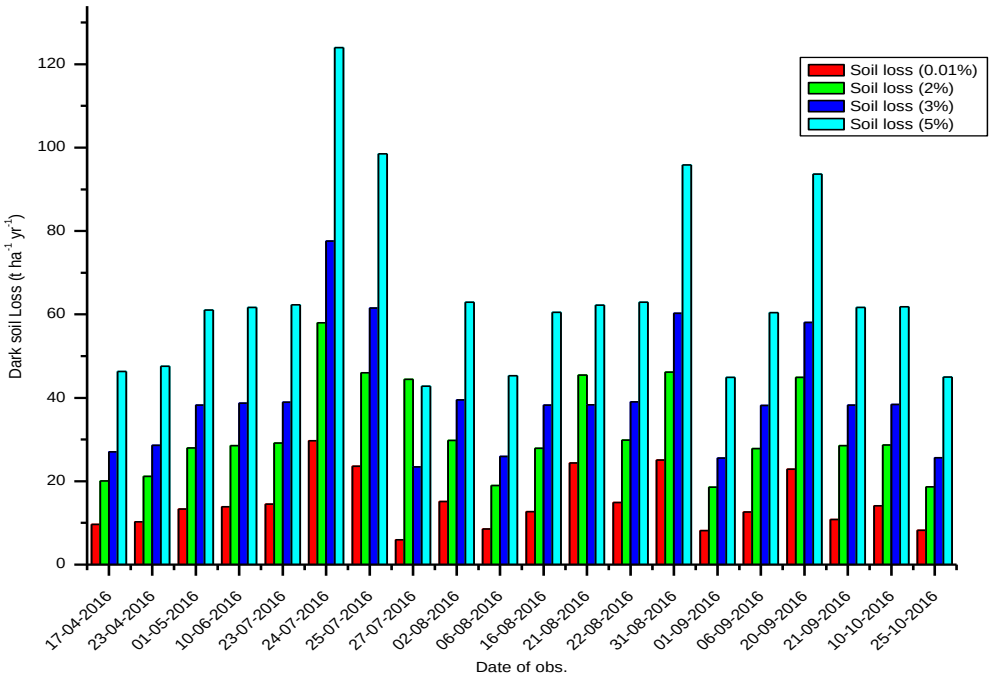

Fig. 4.3.3b: Impact of different slope steepness on dark soil loss at 40 ft slope length during November 2015 to October 2016 at Chandel

Table 4.3.3 showed the observation of highest rainfall intensity on 24th July 2016 with 32.6mm/hr and least rainfall intensity 6.7mm/hr on 27th July 2016. For red soil, the soil loss of 0.01% slope was observed with a range of 3.69 t $ha^{-1}yr^{-1}$ to 21.70 t $ha^{-1}yr^{-1}$; 2% slope soil loss was in the range between 09.15 t $ha^{-1}yr^{-1}$ to 42.56 t $ha^{-1}yr^{-1}$; for 3% slope it was in between 15.98 t $ha^{-1}yr^{-1}$ to 56.81 t $ha^{-1}yr^{-1}$ and for 5% slope the soil loss was observed in the range between 31.97 t $ha^{-1}yr^{-1}$ to 91.11 t $ha^{-1}yr^{-1}$. Incase of dark soil for 0.017 slope the soil loss was scored highest 29.68 t $ha^{-1}yr^{-1}$ on 24th July 2016 with an intensity of 32.6mm/hr and lest 5.97 t $ha^{-1}yr^{-1}$ on 27th July 2016 with an intensity of 6.7mm.hr. For 2% slope, the soil loss accounts highest 58.03 t $ha^{1}yr^{-1}$ with the rainfall intensity of 32.6mm.hr and least 18.57 t $ha^{-1}yr^{-I}$ with the intensity of 9.6mm.hr and for 3% slope, the soil loss was observed highest 77.55 t $ha^{-1}yr^{-1}$ with the rainfall intensity of 32.6mm/yr and least 25.54 t $ha^{-1}yr^{-1}$ with the intensity of 9.6mm/hr. Regarding 5% slope the soil loss was observed in range between 42.80 t $ha^{-1}yr^{-1}$ to 124.01 t $ha^{-1}yr^{-1}$. The observed data on impact of different slope steepness on soil loss at 40ft slope lengths.

The Soil Loss Equations was developed for calculation of field loss in the Corn Belt in 1940. The Universal Soil Loss Equation (USLE) was first developed at the National Runoff and Soil Data Centre which was established in 1954 by the Science and Education Administration in cooperation with Produce University. The USLE is an erosion model designed to predict the longtime average soil losses in runoff from specific field areas in specified cropping and management systems. Widespread field use has substantiated its usefulness and validity for this purpose. It is also applicable for such nonagricultural conditions as construction sites. The major purpose of the soil loss equation is to guide methodical decision making in conservation planning on a site basis. The equation enables the planner to predict the average rate of soil erosion for each of various alternative combinations of crop system, management techniques and control practices on any particulars site. When these predicted losses can be compared with a soil loss tolerance for the site, they provide specific guidelines for affecting erosion control within the specified limits.

The soil loss equation is

A= RKLSCP

where

A, is the computed soil loss per unit area, expressed in the units selected for K and for the period selected for R. In practice, these are usually so selected that they compute A in tons per acre per year, but other units can be selected.

R, the rainfall and runoff factor is the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such runoff is significant.

K, the soil erodibility factor, is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6-ft length of uniform 9-percent slope continuously in clean-tilled fallow.

L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6ft length under identical conditions.

S, the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9 percent slope under otherwise identical conditions.

C, the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.

P, the support practice factor, is the ratio of soil loss with a support practice like contouring, strip-cropping, or terracing to that with straight-row farming up and down the slope.

USLE analysis includes R factor, K factor, LS factor, C factor and P factor values which are determined and maps are generated using GIS. Rainfall erosivity factor (R) R factor is calculated based on IMD data over a period of 30 years of study area. The annual average rainfall erosivity factor (R) was found to be in the range of 697.48 to 710.16 mt $ha^{-1}cm^{-1}$. Many studies (Jain *et al.*, 2001; Dabral *et al.*, 2008) revealed that the soil erosion rate in the catchment is more sensitive to rainfall. The daily rainfall is a better indicator of variation in the rate of soil erosion and seasonal distribution of sediment yield. While the advantages of using annual rainfall include its ready availability, ease of computation and greater regional consistency of the exponent (Shinde *et al.*, 2010). Therefore, in the present analysis, average annual (obtained by total rainfall divided by the total number of rainy days) rainfall was used for R factor calculation. Similar kinds of R-factor values were also calculated by Tirkey *et al.* (2013) and Behera (2015).

The soil-erodibility factor (K) is represented by the susceptibility of the soil for erosion, conveyance of the detached soil and runoff resulted from rainfall. Chance of detachment of soil particles depend upon the structure, infiltration, optimum moisture content, water retentions, presence of cations, texture and composition. Soil erodability (K) of the study area was calculated using the relationship between soil texture class

and organic matter content proposed by Schwab *et al.* (1981); Stone and Hillborn (2000). From the study, it has been found that, in low relief areas like alluvial plains, hills and flood plains region, the K value varies from 0 to 0.36. Soil erodibility is comparatively high (0.88 to 1.1) because soils texture are course and generally loamy sand to sandy loam in texture and organic matter content was very low, which make more susceptible to erosion. The percentages of organic matter in soil drops erodibility, declines susceptibility of soil detachment, but enhances infiltration rates, hence the runoff by reducing erosion (Behera, 2015; Singh *et al.*, 2002).

Topographic factor represents the influence of slope length (L) and slope steepness (S) on erosion process. LS factor was calculated by considering the flow accumulation and slope in percentage as an input. From the analysis, it is observed that the value of topographic factor increases in a range of 5 to 50 as the flow accumulation and slope increases. For study area maximum slope is observed to be 0-5%. It was found that the maximum slope varied in undulated hillock or hills side slope and foothills. According to slope map it was observed that slope at the study area is low. Analysis of the topographic factor is very important in USLE application, since this parameter characterizes surface runoff speed and quantity of sedimentation. Relationship of soil slope on topography established in different condition by Yildirim (2012) and Ozsoy *et al.* (2012).

Land use and land cover is a better understanding of the land utilization aspects of cropping pattern, fallow land, forest, wasteland and surface water bodies, which are vital for developmental planning and erosion studies. The study area has been classified into three land use classes which were assigned to different land use patterns using the values given in Table 4.3.4. Using land use-land cover map, C factor map was prepared and shown in Figure 6. C factor map shows that study area consists of high percentage vegetation cover which will reduce soil erosion (Renard *et al.*, 2011). Soil loss is very sensible to land cover in addition to relief (Chatterjee *et al.*, 2014). In the present study

almost 50% of the area is under forest. C factor is less significant when land use and land cover area comprises maximum percentage of natural vegetation and plantation crops. The value of which ranges from '0' in water bodies to slightly greater than '1' in barren land (Toy *et al.*, 2002).

Table 4.3.4: Land use/land cover classes and respective C-factor value

C-Classes	C-factor	Area (ha) %	TGA
Forest	0-0.2	12280	49.9
Fallow land	0.2-0.4	1533	6.24
Agricultural area	0.4-1.0	10748	43.7
Total		24561	100

*TGA-Total Geographical Area Support practice factor (P)

The average annual soil erosion potential has been computed by multiplying the developed raster data from each factor of USLE analysis. The potential soil loss in the study area has been categorized into seven types viz., very slight, slight, moderate, moderate severe, severe, very severe and extremely severe erosion based on the rate of erosion (t/ha/year), i.e., More erosion corresponds to very high erosion and least rate of erosion correspond to low erosion (Table 4.3.5). It is observed that few parts of the study area have higher values of soil loss, which may be due to the steep slope and poor vegetation. It is observed that most part of the study area around 93.03% comes under low erosion category due to low slope variability. Negligible soil loss areas (5-10 t/ha/yr) have been recorded under forest and low land area. Soil erosion rate was predicted moderately high (10-15 t/ha/yr) for upland agriculture, which needs proper soil conservation measures to reduce the erosion. The high rate (20-80 t/ha/yr) of soil erosion was found in hills side slopes, foothills, barren and fallow land and sand bar of along the coastal basin (Behera, 2015; Mishra and Das, 2017).

Table 4.3.5: Soil loss classifications according to the erosion risk classes

Erosion classes	Area (ha)	% TGA
Very low	22330	90.91
Low	721	2.93
Moderate	522	2.12
High	548	2.23
Very high	440	1.79
Total	24561	100

Table 4.3.5 revealed the soil loss classification according to the erosion risk classes with 23051 ha (93.03%) land has low erosion risk and 522 ha (2.12%) are moderate and 988 ha (3.72%) are high erosion risk category based on variable climatic, soil and topographical condition. The average annual soil loss map is very useful to adopt soil conservation measures and protective method of agriculture practices for sustainable natural resource management.

4.4. EXPEDIENCY ON SUSTAINABILITY OF THE NATURAL RESOURCES OF CHANDEL DISTRICT

a. Determination of Sustainability on Total Land Area of the Chandel District

The population of Chandel district in 1991 recorded 71,014 persons and331300 hectares of total land area. The calculated value of ecologically productive land per capita accord 4.66 hectares and ecologically deficit land per capita as 2.66 hectares. The ecologically deficit land per capita in percent available in decades and annum compute as 57.08 and 5.7 respectively. The district recorded a population of 1,18,327 persons and 3,31,300 hectares in total land area in 2001. The calculated value of ecologically productive land per capita accord 2.79 and ecologically deficit land per capita accord -0.79 and their percentage available in decades as 28.66 and 2.8 in annum. In 2011, the population of the district recorded 1,44,028 persons and 3,31,300 as total land area and calculated value of ecologically productive land per capita as 2.30 and ecologically deficit land per capita as -0.30 with corresponding percent available in decades as 13.04 and percent available in annum as only 1.3 (Table 4.4.1). The elucidated data were portrayal in Fig. 4.4.1.

Table 4.4.1: Determination of Sustainability on Total land area for developments planning of Chandel District

Year	Total population (TP) in Nos.	Total area (TA) in Ha	Ecologically Productive land per capita (EPLC) in Ha	Ecologically Deficit Land per Capita (EDLC			
				In Ha	In % available in decadal EDLC	In % available in annum	Remark
1991	71,014	3,31,300	4.66	-2.66	57.08	5.7	Assuming 2 Ha as foot print
2001	1,18,327	3,31,300	2.79	-0.79	28.06	2.8	
2011	1.44,028	3,31,00	2.30	2.30	13.04	1.3	

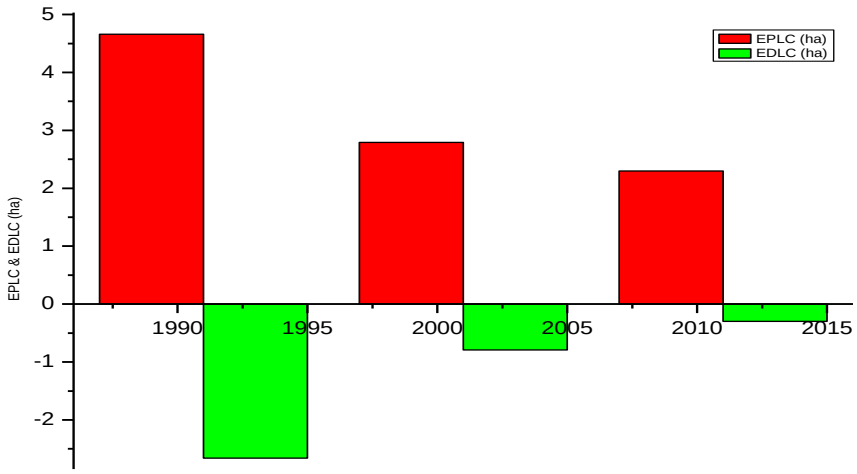

Fig.4.4.1: Plot on ecologically productive land per capita and ecologically deficit land per capita on total land area for developmental planning of Chandel district

The sustainability of the district under "Sustainable Development" was computed following the criteria for sustainable development by Mural (2005) with respect to Global Environment and Population carrying capacity. As per criteria, human activity of population increases in less than 0.5% p.a, between 1.0 to 1.5% p.a. and greater grumped than 2% p.a. were categorized as sustainable, critical and destructive respectively.

Table 4.4.1 revealed that the population, total land area, ecologically productive land per capita and different components of ecologically deficit land per capita etc. of the Chandel district during 1991, 2001 and 2011. The total land area of the district was

3,31,300 hectares. But the population of the district recorded 71,014 nos. in 1991 and 1, 18,327 nos. in 2001 and 1,44,028 in 2011. The finding explored the population of the district increases tremendously but the total land area remains the same. The ecologically productive land per capita was 4.66 hectare in 1991, 2.79 hectare in 2001 and 2.30 hectare in 2011.

The ecologically deficit land per capita was -2.66 hectare with corresponding percent available in decades as 57 and in annum as 5 in the year 1991. During the year 2001, the ecologically deficit land per capita was -0.79hectare with corresponding percent available in decades as 28 and 2 in annum. The ecologically deficit land per capita was -0.30 hectare and their percent available in decades as 13 and 1 in annum. The finding highlighted the value of ecologically deficit land per capita as negative which indicates the district was in the condition of sustainable status as per criteria of Murai (2005). Ecological footprint being the corresponding area of productive land required to produce the resources used and to assimilate the waste produced by a defined population at a specified material standard of living, wherever on Earth that land may be located (Pearce, 1994 & Rees 1992). In this connection, Meadows (1995) rightfully stated that the current situation would lead to "Overshoot and collapse" based on the present trend of population increases, industrial production, metal consumption of natural resources including deforestation, if it is very rapid, it automatically pushes up the carrying capacity very quickly, but only in very short term. The present finding highlighted that the sustainability status of the district should be maintain for the next future generation so as to control the expansion and increases of population growth by using various population control technique. If the population increases in this current trend, the district would reached the critical and destructive stage in very short term. The present finding highlight a cautionary signal in certain commodities and resources and suggestions to a variety of concrete sustainability guidelines and supports to broadly based programme of reform that could redirect us in the direction of development progress by right utilization of resources and conservation.

b. Determination of sustainability on total forest area for developmental planning of Chandel district

Forests provide many benefits to the human population. They help clean air, protect watersheds, are one of the most important renewable resources for meeting many human needs and provide the place for much of outdoor recreation. For many of us the forests area place of spiritual renewal where we go to get away from the business of, everyday life and connect with the mysteries of the universe. Without forest human life would be much different. Yet because of the size and growth of the human population we are placing tremendous stress on them. The human population is impacting the forest ecology and that in turn is impacting larger ecosystem. It is need to protect forests which are the source for so many benefits for human as well as wildlife.

While population growth dynamic tremendously effect the total forest area and leading to decrease of forests and causing imbalance to environment. Therefore, the present work is to determine the sustainability on total forest area for developmental planning of Chandel district.

The population of Chandel district recorded 71,014 persons in 1991 and total forest area of 3,19,970 hectares. The calculated ecologically productive land per capita accord 4.505 hectares and different components of ecologically deficit land per capita accord- 2.505 hectare, 55% in available in decades and 5% in available in annum. In 2001, the district recorded 1,18,327 persons of population and 2,82,900 hectares of total forest area with calculated ecologically productive land per capita as 2.390 hectare and -0.390 hectare as ecologically deficit land per capita in hectares, 16% in available in decades and I percent in available annum. During the year 2011, the district recorded 1,44,028 persons of population and 2,78,900 hectares of total forests area. The calculated ecologically productive land per capita accord 1.936 hectares and 0.064 hectares, as ecologically deficit land per capita in hectares, 3 percent in available in decades and 0.3 percent in available in annum. (Table 4.4.2). The enlisted data were displayed in Fig.4.4.2.

Table 4.4.2: Determination of sustainability on total forest area for developmental planning of Chandel District

Year	Total population (TP) in Nos.	Total Forest area (FA) in Ha	Ecologically Productive land per capita (EPLC) in Ha	Ecologically Deficit Land per Capita (EDLC)			
				In Ha	In % available in decadal EDLC	In % available in annum	Remark
1991	71,014	3, 19,970	4.505	-2.505	55	5	Assuming 2 Ha as foot print
2001	1,18,327	2, 82,900	2.390	-0.390	16	1	
2011	1,78,900	2, 31,300	1.936	-0.064	3	0.3	

Sources: State Forest Report

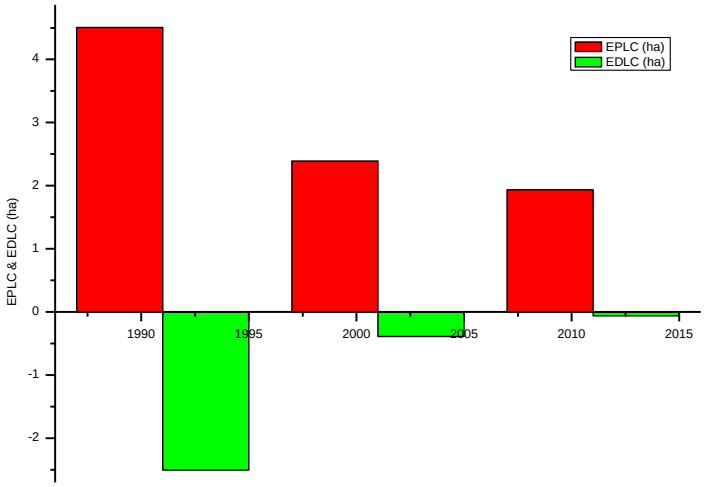

Fig.4.4.2: Plot on ecologically productive land per capita and ecologically deficit land per capita on total forest area for developmental planning of Chandel district

Table 4.4.2 revealed the population, total forest area, ecologically productive land area and different components of ecologically deficit land per capita for the year 1991, 2001 and 2011. The population of Chandel district recorded 71,014 persons and 3,19,970 hectares of total forest area in the year 1991the calculated ecologically productive land per capita accord 4.505 hectares and ecologically deficit land per capita as -2.505 hectares with their percent available in decades as 55% and percent available in annum as 5. On the next decade i.e., 2001 the population was increased 47313 persons (i.e., 71,014 to 1,18,327) and the total forest area was decreased 37,020 hectares (i.e., 3,19,970 to 2,82,900). The calculated ecologically productive land per capita was 2.390 hectares, -0.390 hectares as ecologically deficit land per capita with

their percent available in decade was 16% and 1% as in available in annum. During the year 2011, the population of district was increased 25701 persons (i.e., from 1,18,327 to 1,44,028) and total forest area was decreased 4,000 hectares (i.e., 2,82,900 to 2,78,900). The calculated ecologically productive land per capita as 1.936 hectares and the ecologically deficit land per capita as 0.064 hectares and ecologically deficit land per capita in percent available in decades as 3% and 0.3% as

c. Determination of sustainability on total Jhum area for developmental planning of Chandel District

Shifting cultivation or jhum cultivation is an agricultural system in which plots of land are cultivated temporarily, then abandoned and allow to revert to their natural vegetation while the cultivator moves on to another plot. The period of cultivation is usually terminated when the soil shows signs of exhaustion or more commonly, when the field is overrun by weeds. The length of time that a field is cultivated is usually shortened than the period over which the land is allowed to regenerate by lying fallow (Spencer, 1996). Jhum cultivation was practiced in Chandel district since time immemorial. It is often considered responsible for causing soil erosion, triggering landslide, flash floods and thereby degrading the primary land resources. Earlier the jhum cycle was about 20-30 years, however growing human population and increasing anthropogenic pressure on land has reduced the cycle to 2-3 years, thus resulting in the degradation of the ecology and environment of the hilly region.

The increase in human population has put tremendous pressures on land especially in the hill district of Manipur. The extension of crop lands, for increasing food production has been directly responsible for the reduction in areas under forests and grass lands.

In 1991, Chandel district recorded a total population of 71,014 persons and total jhum area of 3,220ha. The ecologically productive land per capita accord 0.04ha and different component of ecologically deficit land per capita was 1.9547ha, 4315% in available in decade and 431.50% in available in annum. The district accord 1,18,327 persons of total population, 9470ha of total jhum area, 0.08003ha of ecologically

productive land per capita, 1.91997 ha of ecologically deficit land per capita, 2399% of available ecologically deficit land per capita in decade 239.9% of available ecologically deficit land per capita in annum in the year 2001. During the year 2011, the districts accord 1,78,900 persons of total population, 19,308 ha of jhum area, 0.1340 ha of ecologically productive land per-capita, 1392.5ha of ecologically deficit land per capita, 1392.5% of available ecologically deficit land per capita in decade and 139.2% of available ecologically deficit land per capita in annum (Table 4.4.3). The data were displayed in Fig. 4.4.3.

Table 4.4.3: Determination of sustainability on total jhum area for developmental planning of Chandel District

Year	Total Population(TP) in Nos.	Total Jhum area in Ha	Ecologically Productive land per-capita (EPLC) in Ha	Ecologically Deficit Land per Capita (EDLC)			
				In Ha 2-EPLC	In % available in decadal EDLC/EPLC	In % Availablein annum	Remark
1991	71,014	3220.0	0.0453	1.9547	4315.0	431.50	
2001	1,18,327	9470.0	0.08003	1.91997	2399.0	239.9	
2011	1,78,900	19308.0	0.1340	1.866	1392.5	139.2	

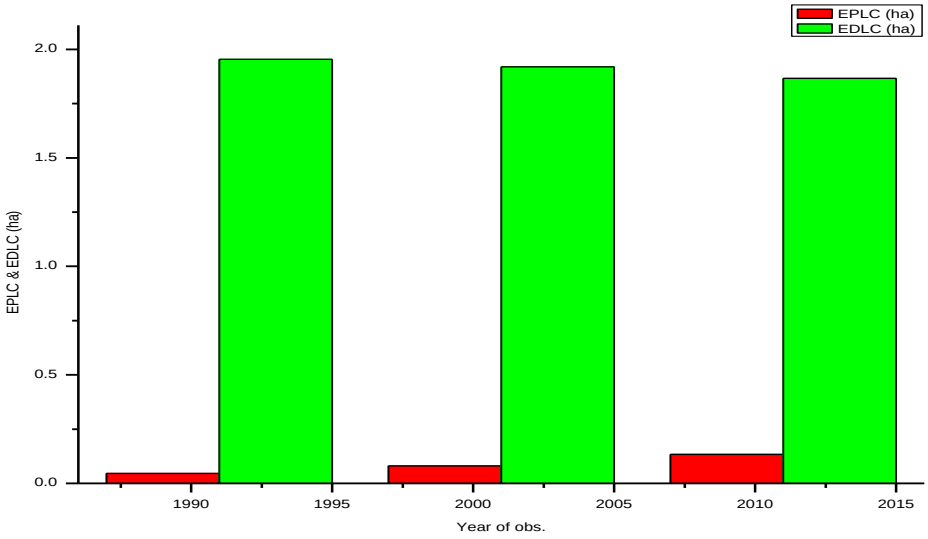

Fig.4.4.3: Plot on ecologically productive land per capita and ecologically deficit land per capita on total jhum area for developmental planning of Chandel district

Table 4.4.3 highlighted the determination of sustainability of total jhum area for developmental planning of Chandel district. In 1991, Chandel district recorded a total population of 71,014 persons and total jhum area of 3,220ha. The ecologically productive land per capita accord 0.04ha and different component of ecologically deficit land per capita was 1.9547ha, 4315% in available in decade and 431.50% in available in annum. The district accord 1,18,327 persons of total population, 9470ha of total jhum area, 0.08003ha of ecologically productive land per capita, 1.91997 ha of ecologically deficit land per capita, 2399% of available ecologically deficit land per capita in decade 239.9% of available ecologically deficit land per capita in annum in the year 2001. During the year 2011, the districts accord 1,78,900 persons of total population, 19,308 ha of jhum area, 0.1340 ha of ecologically productive land per-capita, 1392.5ha of ecologically deficit land per capita, 1392.5% of available ecologically deficit land per capita in decade and 139.2% of available ecologically deficit land per capita in annum.

d. **Determination of sustainability status on population increase in Chandel district**

Chandel district recorded the total population of 24,049 persons in 1951; 27,679 persons in 1961; 38, 723persons in 1971; 56,444 persons in 1981; 71,014 persons in 1991; 1,16,327 persons in 2001 and 1,44,028 persons in 2011. During 1951 to 1961, the population increase was 3630 persons and corresponding percentage per annum assigned 1.50%. The district recorded the population increase was 11,044 which is 3.99% per annum during 1961-1971; 17,721 (4.5% per annum) during 1971-1981; 14,570 (2.58%per annum) during 1981-1991; 47,313 (6.66% per annum) during 1991-2001 and 25,701 (2.17% per annum) during 2001-2011 (Table 4.4.4). The exemplified data were graphically plotted and presented in Fig. 4.4.4.

Table 4.4.4: Sustainable status on population increase in Chandel District

Year	Population (Nos.)	Population increase (Nos.)	Percentage of population increase per	Sustainability status	Remark
1951	24,049	-	-	C	Criteria Sustainable Development SD, Sustainable <0.5% p.a- C, Critical 0. i - 1.5% p.a. D,Destructive72. 0%p.a.
1961	27,679	3630	1.50	D	
1971	38,723	11,044	3.99	D	
1981	56,444	17,721	4.5	D	
1991	71,014	14,570	2.58	D	
2001	1,18,327	47,313	6.66	D	
2011	1,44,028	25,701	2.17	D	

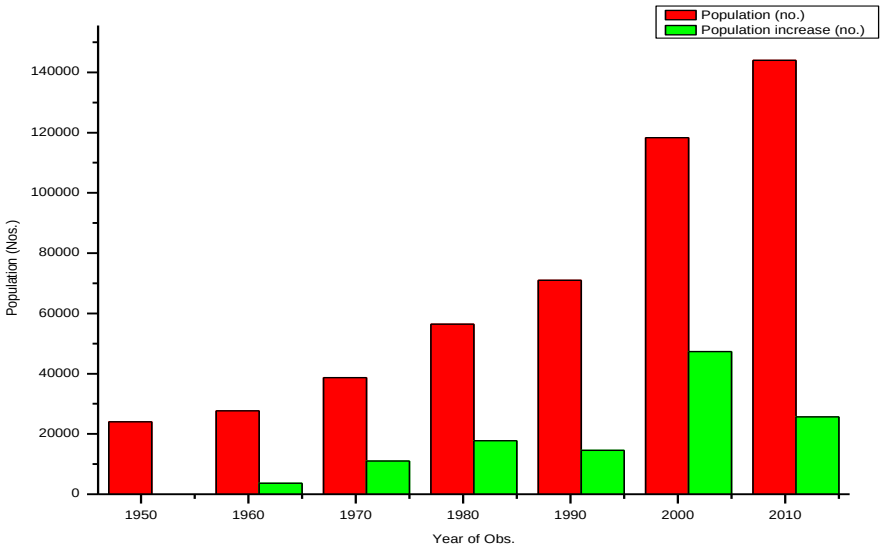

Fig.4.4.4 Sustainable status on population increases in Chandel District

Table 4.4.4 highlighted the sustainability status on population increase in Chandel district. Chandel district recorded the total population of 24,049 persons in 1951; 27,679 persons in 1961; 38, 723persons in 1971; 56,444 persons in 1981; 71,014 persons in 1991; 1,16,327 persons in 2001 and 1,44,028 persons in 2011. During 1951 to 1961, the population increase was 3630 persons and corresponding percentage per annum assigned 1.50%. The district recorded the population increase was 11,044 which is 3.99% per annum during 1961-1971; 17,721 (4.5% per annum) during 1971-1981;

14,570 (2.58%per annum) during 1981-1991; 47,313 (6.66% per annum) during 1991-2001 and 25,701 (2.17% per annum) during 2001-2011

The sustainability of the district under "Sustainable Development" was computed following the criteria for sustainable development by Murai (2005) with respect to Global Environment and population carrying capacity. As per criteria, human activity of population increase in lesser than 0.5% p.a., between 1.0 to 1.5% p.c. and greater gramped than 2% p.c. were categorized as sustainable, critical and destructive respectively.

Table 4.4.4 depicts the total population, population increase, their percentage increase per annum and sustainability status of the Chandel district. During 1951 to 1961, the district recorded the increase population growth per annum as 1.50. Based on the criteria of sustainable development on the percentage of population increase per annum, the district crossed the critical state as its value is within the range of 0.1 to 1.5% per annum. During 1961 to 2011, the district recorded the increase population per annum ranges from 2.17% to 6.66% which is at the destructive state as its values is greater gramped than 2.0% per annum.

5. SUMMARY AND CONCLUSION

1. The population growth dynamics by representation of direct population numbers with initiation from 24.0 thousands at 1951 rises with and grew up to 27.6, 33.7, 56.4, 71.0 thousands at 1961, 1971, 1981 and 1991 and grew up to 1.1 lakhs at 2001 and 1.4 lakhs at 2011 with an increase of 3.6, 11.0, 17.7, 14.5, 47.3 at 1951 to 1961, 1961 to 1971, 1971 to 1981, 1981 to 1991, 1991 to 2001 and with decrease of 25.7 at 2001 to 2011.
2. The calculated projected population of Chandel district was 1,56,037; 1,74,892; 1,93,747 persons in 2022, 2033, 2044 respectively according to arithmetic growth of population. By Odum's the projected population was 1,92,421 in 2022; 2,57,234 in 2033 and 3,43,650 in 2044. The mean projected population of Chandel district was 1,74,229 in 2022; 2,16,063 in 2033 and 2,68,698 in 2044.

3. Total number of villages with number of household located at the five (5) sub-divisions like Machi, Tengnoupal, Chandel, Chakpikarong and Khenjoy at Chandel district. Machi sub-division has only 70 villages with 4069 households. The main source of water in this sub-division was from tap water (1320 households) river (991 household), pond (760 households), spring (601 household), wells (175 households) and tube well (5 households) and others (180 households). Out of these five sub-division, Chakpikarong sub-division have highest number of villages i.e., 133 villages and followed and followed by 98 villages in Chandel, 97 villages in Tengnoupal sub-division, 70 villages in Machi sub-division and only 56 villages at Khenjoy sub-division. These five subdivisions recorded 454 villages in the Chandel district with a total household of 32,185 numbers.
4. The selected 10 (ten) physico-chemical and biological parameters of the tap water, well water, handpump, tubewell, spring water Maha river, Chakpi river, Machi river pond water sample were analysed during October 2015 to September 2018.
5. Water samples were collected from nine different water bodies from Chandel district, summer season (March, April, May) winter seasons (November, December, January, February) and rainy seasons (June, July, August, September, October) with monthly variations during October 2015 to September 2018. For physiochemical and biological analysis of different water bodies, the parameters such as temperature (^{0}C), turbidity (NTU), p^H, dissolved oxygen (D.O.) (mg/l)), biological oxygen demand (B.O.D.) (mg/l), total hardness (mg/l), Calcium (mg/l) magnesium (mg/l) were analysed.
6. The calculated Water Quality Index (WQI) based on observed values (V_n), standard values (S_n), Unit Weight (W_n) and quality Rating (q_n) of different water bodies of Chandel district for three different seasons like summer season, winter season and rainy seasons were investigated.
7. Twenty (20) observations under rainy days were selected for experimentation level of rainfall, rainfall intensities, kinetic energy (K.E.) and erosion index (K.I). The rainfall in 30 min observed with a range between 13.4mm to 53.6mm. The rain intensity in cm/hr was observed 3.2cm/hr as the highest intensity and 0.6cm/hr as the lowest intensity. Likewise, the rain intensity in mm/hr was in the range between

6.7mm/hr to 32.6mm/hr. The Kinetic energy (K.E) of each rainfall intensity was calculated with a range between 283.82Mt ha^{-1} to 344.97Mt ha^{-1}. The erosion index (KI) scored highest with a value of 1103.90Mt $ha^{-1}cm^{-1}$ and lowest n170.29Mt ha^{-1}.

8. The runoff in red and dark soils with effect of different slope length at 2% slope gradient was observed from rain intensity and calculated by using dimensionless coefficient, C=0.20 for red soil and C=0.30 for dark soil.

9. The soil loss classification according to the erosion risk classes with 23051 ha (93.03%) land has low erosion risk and 522 ha (2.12%) are moderate and 988 ha (3.72%) are high erosion risk category based on variable climatic, soil and topographical condition. The average annual soil loss map is very useful to adopt soil conservation measures and protective method of agriculture practices for sustainable natural resource management.

10. the population, total land area, ecologically productive land per capita and different components of ecologically deficit land per capita etc. of the Chandel district during 1991, 2001 and 2011. The total land area of the district was 3,31,300 hectares. But the population of the district recorded 71,014 nos. in 1991 and 1, 18,327 nos. in 2001 and 1,44,028 in 2011. The finding explored the population of the district increases tremendously but the total land area remains the same. The ecologically productive land per capita was 4.66 hectare in 1991, 2.79 hectare in 2001 and 2.30 hectare in 2011.

11. The population, total forest area, ecologically productive land area and different components of ecologically deficit land per capita for the year 1991, 2001 and 2011.

12. The determination of sustainability of total jhum area for developmental planning of Chandel district. In 1991, Chandel district recorded a total population of 71,014 persons and total jhum area of 3,220ha. The ecologically productive land per capita accord 0.04ha and different component of ecologically deficit land per capita was 1.9547ha, 4315% in available in decade and 431.50% in available in annum. The district accord 1,18,327 persons of total population, 9470ha of total jhum area, 0.08003ha of ecologically productive land per capita, 1.91997 ha of ecologically deficit land per capita, 2399% of available ecologically deficit land per capita in

decade 239.9% of available ecologically deficit land per capita in annum in the year 2001. During the year 2011, the districts accord 1,78,900 persons of total population, 19,308 ha of jhum area, 0.1340 ha of ecologically productive land per-capita, 1392.5ha of ecologically deficit land per capita, 1392.5% of available ecologically deficit land per capita in decade and 139.2% of available ecologically deficit land per capita in annum.

13. During 1951 to 1961, the district recorded the increase population growth per annum as 1.50. Based on the criteria of sustainable development on the percentage of population increase per annum, the district crossed the critical state as its value is within the range of 0.1 to 1.5% per annum. During 1961 to 2011, the district recorded the increase population per annum ranges from 2.17% to 6.66% which is at the destructive state as its values is greater gramped than 2.0% per annum.

5. REPORT ON WORSHOP PROGRAMME

On Saturday 22nd October 2016, a One-day Workshop Programme was conducted at the Seminar Hall of the South East Manipur College, Komlathabi, Chandel, Manipur under the present major research project (vide order no. F.No.43-330/2014 (SR) dated 24'" September 2015). The organization of workshop with relation to resource conservation entitled ***"The role*** *of* ***indigenous people on conservation*** *of* ***water and soil"*** have conducted as per schedule time. The programme was sharply started at 10a.m. with registration of delegates, arrival of VIPs, invitees, resource persons and participants. After arrival of VIPs, the Chief Guest, President and Guest of Honour, call upon the dignitaries on dais for their respective chairs. First of all, Mr. Moshilpha, a student of B.Sc. 3rd semester, SEMCO, Komlathabi, appreciated all the persons gathering in the hall with pleasant and warm welcome address. Then bouquets and rosettes to the VIPs on the dais with respect and honour have presented. I, Dr. Th. Manimala Devi, Principal Investigator, UGC- Major Research Project under UGC vide order no. F.No.43- 330/2014(SR) dated 24th September 2015 and Assistant Professor, Department of Environmental Science as well as Nodal Officer UGC-B.Voc. Degree Programme delivered key note address. On the key note address the P.I. mention about importance of soil and water, conservation of soil and water etc. have briefly noted

down in the introductory part and draws the attention of the spectators. Mr. Roel Komon, Guest of Honour, delivered a general speech on the pollution of water and soil by human being. Mr. Roel Jindashing, Chief Guest, Village Chief of Komlathabi village, delivered his inaugural address describing about water and soil. Dr. L. Khiloni, Principal, South East Manipur College, Komlathabi delivered her Presidential address elucidating the modern trend of fast changing population and its impact on water and soil and thereof the role of youths, students and indigenous people for the protection and conservation of water and soil. Three resource persons delivered lectures on the topic "Water conservation for future generation", "Interrelationship between water and soil pollution and human being" and "An awareness to the indigenous people about water and soil". After lectured from resource person, an interaction programme was conducted amongst the resource persons, students, local people as well as the participants of the programme. The one day workshop programme give a detail Awareness on the role of people for conservation of water and soil to all the participants and then workshop programme was closed at around 4.30 p.m. with vote of thanks by Roel Kamonden, a student of 3rd Sem. B.Voc. Information and IT services, SEMCO, Komlathabi. The workshop programme ice break the silently sleeping mindset of participants to take of a break through towards the indispensability's of water and soil.

On the theme, ‘the role of indigenous people on conservation of water and soil’, the Principal investigator and project fellow conducted such one day workshop programme at two different sites of Chandel district, one at the Moreh College, Moreh, Tengnoupal sub-division and another at United College, Chandel, Manipur with indigenous local people mainly literate and illiterate people, professionalist, agriculturalist, industrialist, horticulturist etc.

7. PREPARATION FOR PUBLICATION

With the advancement of Investigation works under the project the following topics have prepared for publication.

i) A framework of sustainability on population growth dynamics of Chandel district, Manipur

ii) Assessment of physico-chemical and biological parameters of water of the three different rivers of Chandel district, Manipur

iii) Slope lengths effect on soil loss by using universal soil loss equation in Red soil in Chandel district, Manipur

PHOTO GALLERY

Plate 1: Collecting water sample for monitoring of physico-chemical and biological water analysis from pond, Chandel district

Plate 2a: Collecting water sample for analysis of physico-chemical and biological water parameters from hand pump, Chandel district

Plate 2b: Collecting water sample for analysis of physico-chemical and biological water parameters from handpump, Chandel district

Plate 3: Water quality testing at monitoring site, Chakpi river, Chandel district

Plate 4: Water quality testing at monitoring site, Machi river, Chandel district

Plate 5: Experimentation water quality parameters at laboratory

Plate 6: Experimentation water quality parameters at laboratory

Plate 7: Recording evaporation of water from Pan at the hill of Chandel district

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LIST OF PUBLISHED PAPERS OF DR. THOKCHOM MANIMALA DEVI

Sl . No.	Title	Year	Journal	Level (National /International)
1.	A Framework and Eco-computation of Carrying Capacity on Food Resources of Thoubal District, Manipur	2006	J. Phytol Res. 19(1): 119-123	National
2.	Sustainability through Environmental Conservation of Agricultural Land Resources	2007	The Bioscan 2(4):319-322	International
3.	Sustainable development of Environmental Conservation on Natural Land Resources and Population Through Carrying Capacity and Footprints	2008	Indian J, Environ & Ecoplan (ISSN 0972-1215)	National
4.	Assessment of Physico-Chemical and Biological Parameters in Kongba River Water, Imphal East District, Manipur	2011	Indian J, Environ & Ecoplan (ISSN 0972-1215)	National
5.	Change in Temperature, Precipitaiton, Certain Resources their Impact on Environment, Accounting to Habitats Patterns in Manipur Since 1873-A Climate Changes Study	2011	Indian J, Environ & Ecoplan (ISSN 0972-1215)	National
6.	Insect Pest Management of Rice (*Oryza sativa*) Paddy in the Chandel District	2015	National Seminar "Insect Plant Interaction". 42-49pp	National
7.	Physico-chemical and Biological Analysis of Maha River, Chandel District for conservation of Natural Resources	2018	National Seminar "Understandin g Water Pollution ….Chandel District, Manipur. 47-51pp	National
8.	A framework of sustainability on population growth dynamics of Chandel district, Manipur	2019	Research Monograph. 2010. 13.HRDRI, Canchipur	Published

9.	Assessment of physico-chemical and biological parameters of water of the three different rivers of Chandel district, Manipur	2022	Indian J. of Env. And Eco. Planning	Communicated
10.	Slope lengths effect on soil loss by using universal soil loss equation in Red soil in Chandel district, Manipur	2022	ECOSCAN	Communicated

QUESTIONNAIRE & SCHEDULE ON NATURAL SOIL & LAND RESOURCES

1. Name of the district :……..
2. Name of the Sub-division :……..
3. Name of the Block : …….
   a. Weather it is
      i) Village _____ ii) SDC_____ iii) SDO_____
4. Name of the Household :……..
5. Occupation :……
6. Total No. of family members :
   a) Adult: _____ Male:_____ Female :_____
   b) Children : _____ Male : _____ Female : _____
7. Total No. of Live stocks:
   a) Ox _____ b) Pig_____ c) Poultry ____ d) Duckery _____
   e) Goat ____ f) Dog _____ g) Cats _____ h) Others _____
8. Area occupied by cultivated land :
   a) Agriculture _____ b) Horticulture: __ c) Kitchen garden ___
   d) Others (Livestock's etc.)_____
9. Mode of cultivation: _____ (Zoom/ Normal) _____
10. Slope of the land:
    a) 0-5% _____ b) 5 to 10% ____ c) 10 to 20% _____
    d) 20-30% _____ e) 40-50% _____

Name of Investigator Starting Time _____

Date: _____ Ending Time _____

Hello, my name is _____ and I work for, Project Assistant, a major Research Project that is collecting information on drinking water services in _____ . May I speak to an adult member of your household.

11. Type of the land:

    A) Foothill _____ b) Hill slope _____ c) Hillock _____

    D) Plain _____

12. Type of crops grown

    a) Cereal crops (Rice/Wheat/ Maize) _____

    b) Pulses (Urd/ soybeans) _____

    c) Vegetables (Cabbage/mustard) _____

    d) Cash crops (Sugarcane) _____

    e) Oilseed (Mustard) _____

    f) Others _____

13. Season of crop grown

    a) Kharif _____ b) Rabi _____ c) Zaid _____

    d) Summer _____ e) Winter _____ f) Rainy _____

14. Type of soil:

    a) Red ____ b) Loam _____c) Clay _____d)Sand _____

    e) Mix_____

15. Preparation of soil:

    a) Manual _____ b) Animal _____ c) Power _____

16. No. of days for preparation of soil

    a) Manual _____ b) Animal _____ c) Power _____

17. Type of tools/Machines used for:

    a) Manual _____ b) Animal _____ c) Power _____

18. Method of field practice:

    a) Terrace cultivation _____

    b) Plain cultivation _____

    c) Others _____

19. Mode of farming :

    a) Single _____ b) Double _____ c) Triple _____ d) Multiple _____

20. Irrigation system :

    a) Practice _____ b) Not Practice _____

21. If practice type of irrigation:

    a) Pump ____ b) Well ____ c) Manual ____ d) River ____ e) Spring _____

22. Fertilization

    a) Use _____ b) Not use _____

23. If used type of fertilizer :

    a) Urea _____ b) Phosphorus _____ c) Potash _____ d) Diamond

    e) Others _____

24. Type of sowing/Seedling

    a) Manual _____ b) Machine _____

25. Type of weeding

    a) Manual _____ b) Machine _____

26. Type of harvesting

    a) Manual _____ b) Machine _____

27. Means of Post-Harvest

    a) Transportation

    i) Manual _____ ii) Animal _____ b) Power _____

    b) Storage

    i) Bin _____ii) Mud _____ iii) Plank _____ iv) Basket _____

    v) Others _____

28. Mannuring

    a) Use _____ b) Not use _____

29. If used type of manure

30. a) Gram manure _____ b) Farm yard manure _____

    c) Others _____

QUESTIONNAIRE ON DRINKING WATER

1. What is your name:……..
2. Gender : a) Male _____ b) Female _____
3. What is your age _____
4. Location/Address _____
5. Type of family a) Nuclear _____ b) Joint _____
6. Total no. of family members _____

   a) Adult male _____ b) Adult Female _____

   c) Male children _____ d) Female Children _____
7. How many members in the household are employed: …….
8. What is the monthly household income? …….

   a) <1000 Rs. _____ b) 1001- 2500 Rs. _____

   c) 2501_____ 500 RS. _____ d) > 1000Rs. ____
9. Which of the following sources of drinking water are available in your neighbourhood?

   a) Hand pump _____ b) Well _____ c) Spring _____

   d) Stream _____ e) Pond _____ f) River _____
10. Which of the following sources of drinking water does your household use?

    a) Hand pump _____ b) Well _____ c) Spring _____

    d) Stream _____ e) Pond _____ f) River _____
11. How far (in metres) the source of water that you use? _____
12. How long (in metres) does it take to fetch water and return home? _____
13. Who fetch water most often?

    a)Adult male _____ b) Adult female _____

    c) Male child _____ d) Female child _____
14. Which month do you face scarcity? _____
15. How does the water smell?

a) No smell _____ b) Foul smell _____

16. Does the water have a taste? _____

a) Yes _____ b) No. (tasteless) _____

17. What does the water looks like?

a) Clear _____ b) Dirty _____

18. Do you pay for water? _____

19. How much do you pay a month? _____

20. Are the bills that you receive accurate? _____

a) Yes _____ b) No._____

21. Have you made a complaint related to your drinking water service in the past one year?

a) Yes b) No.

22. What was the result of the complaint?

a) Prompt action taken b) Delay action taken c) No action taken

23. Are you satisfied with your drinking water?

a) Satisfied b) Dissatisfied

24. What is the extent of your satisfaction?

a) complete b) Partial

25. What are the reasons for your dissatisfaction? (3 points)

a.
b.
c.

26. Name you paid a bribe for any service related to drinking water in the last one year? _____

27. For what purpose have you most recently paid a bribe? ……

28. How much did you pay? ……..

29. Did you pay on your own?

a) Demanded b) Paid on my own

30. Did the work get done after paying the bribe?

a) Yes _____ b) No _____

Leaflet -1
Natural Resources Conservation regarding Conservation of Water for Future Generation

Curricular distribution for Awareness of Soil, Water and Forest Conservation under UGC – MRP)

Water conservation refers to any beneficial reduction of water usage, loss or waste. It also includes the strategies and activities to manage and protect water resources to meet the demand for human consumption. It involves reducing the usage of water and recycling of waste water for various purposes such as cleaning, irrigation and manufacturing. Another method for implementing water conservation is by improving water management practices. This improves the use of water resources to benefits people and the environment. Consuming water is important because water is a finite and vulnerable resource that sustains life, economic development and the environment.

Waters conservation includes all policies, strategies and activities made sustainably manage the natural resource fresh water, to protect the water environment, and meet the current and future human demand. Population, household size and growth and affluence all affect how much water is used.

The goals of conserving water are –

- Ensure availability of water for future generating where the withdrawal freshwater from en ecosystem does exceed its natural replacement mate.
- Energy conservation as water pumping delivery and wastewater treatment facilities consume a significant amount of energy.
- Habitat conservation where minimizing human water use helps to prose freshwater habitats for local wildlife migrating waterfowl but also water quality.

Following are water-saving technology for the home

- Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy.
- Low-flush toilets and composting toilets
- Dual flush toilets created by caroms include two buttons on handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets.
- Raw water flushing where toilets use non-purified water.
- Reuse of gray water for flushing toilets or watering gardens
- High efficiency clothes washes
- Weather based irrigation controlling
- Low flow taps in wash basing
- Swimming pool covers that reduce evaporation and can warm pool water to reduce
- Waterless car washes
- Always turn taps off tightly so they do not drip
- Promptly repair any leaks in and around your taps
- Use only cleaning product that will not harm the environment when they are washed away after use
- Look for "environmentally friendly" products when shopping
- Use shut-off timers or on-off times, if possible do not turn on sprinkles and leave for the day.
- Lawns and gardens require only 5 millimeters of water per day during warm weather. Less is needed during spring, fall or cool weather
- When brushing our teeth, turn the water off while we are actually brushing
- Wash only full loads in our washing machines
- Use brooms or other tools to clean gutters in lead of the water hose
- Keep in mind those hidden water sources, including broilers and hot water heat pumps
- Consider all decorations used outside including water fountains that may consume more energy
- Consider purchasing a dual-flush toilet
- Use rainwater to water the plants in the house

- Reuse our towels, using them a couple of times is perfectly fine and a great way to same water
- Do not plant in areas that are hard to water
- Teach our kids to turn the faucets off tightly after each use

Reasons for importance of water conservation for our family

- Without fresh water we will die in just a few days. Plain and simple no sugar coating, it is a simple morbid fact that helps drive the points across, water equals life.
- Using less water keeps money in our pocket. By utilizing basic water conservation techniques we are able to same thousands of gallons of water each day.
- Conserving water can also save energy. In order to pump water from a central facility into our home or office, energy is required to run that equipment.

Save Water- Don't Waste the World's blood

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Leaflet -2
Natural Resources Conservation w.r. to Forest Conservation

(Circular distribution for of soil, water and forest conservation under UGC-MRP)

Forest conservation is the practice of planting and maintains forest area for the benefit and sustainability of future generation. The conservation of forests also stands and aims at a quick shift in the composition of trees species and age distribution. Forest conservation involves the upkeep of the natural resources within a forest that are beneficial to both human environments. Forests are vital for human life because they provide a diverse range of resources i.e., they store carbon dioxide and act as carbon sink, produce oxygen which is vital existence of life on the earth so they are rightly called as earth lungs, help in regulating hydrological cycle, purify water, provide wild life reduce global warming, absorb toxic gases and noise, reduce pollution, conserve soil, mitigate natural hazards such as floods a landslides and so on.

Formerly forests were supposed to be a civilization. But recently we have realized that trees are very valuable resources for man food, fuel, fodders, fertilizer, paper, honey, wax, medicine and many other useful things moreover a grown-up tree is worth amounting to sixteen lakhs of rupees approximately if we consider its gifts of oxygen, fruit, fuel etc. for about fifty years.

Ecological studies have shown t forests help to maintain the optimum level rainfall for agricultural purposes, constructing dams and hydroelectric project etc. They play a paramount role in checking the floods and soil erosion. They are also important for wild life, human recreation and preservation of balanced environment. Above all, forest brings clouds and clouds bring rain and rain brings our harvest.

It is interesting to note that one-third land is required as forests in any country to maintain ecological balance. Otherwise the whole universe with its dust, smoke, noise and bustle will choke human society

One half of the world's forests have been destroyed in the last 10,000 years – the majority of this loss has occurred in just the last 50 years, occurring simultaneously with a massive increase in the human population. The incredible scale of this loss has led to significant changes throughout many parts of the world, and in recent years there changes have been accelerating deforestation essentially leads to extinction of vital things and destroys the ecological balance of nature. Thus causing –

Heavy soil erosion: The roots of the trees hold the soil firmly keeping it infact. With large scale deforestation soil erosion and landslides have become a normal phenomenon. During heavy rains and typhoons soil is washed away lo lower regions. This increases the risk for landslides which can cause seriously threaten the safety of the people and damage their properties.

Extinction of flora and fauna: Destruction of the forests leads to a tragic loss of biodiversity. Millions of plants and animals species are on the verges of extinction due to deforestation

Global warming: the trees absorb the harmful CO_2 and release the life sustaining O_2. Thus, acting as natural friends of humans. Deforestation increases the amount of CO_2 in the atmosphere leading to global warming due to greenhouse effect.

Flooding: Trees absorb water in large quantities during heavy rain. But due to large scale deforestation there are very less trees to retain water. This again leads to heavy floods causing ᴅavy loss of life and property.

The harmful effects of deforestation are much that all over the world people and

authorities have realized that forest resources must be conserved properly in order to protect t ecosystem. Therefore following are the steps to be taken up for the conservations of forests:

- Regulated and planned cutting of trees
- Control over forest fire
- Reforestation and afforestation
- Check over forest clearance for agricultural and Habitation purposes
- Protection of forests
- Proper utilization of forest products and forests
- Indiscriminate deforestation should be prohibited
- Wastage of timber and fuel wood to be avoided
- Alternative sources of energy such as biogas should be used to supplement wood
- Forest fires should be prevented
- Pests and diseases of the forest trees should be controlled chemically and biologically
- Grazing of cattle in forests should discouraged
- Operations called improved cutting selective cutting should be adopted forest managements

F

FEEL FREE TO PLANT A TREE

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