Journal of ENVIRONMENTAL Treatment Techniques

Enviro. Treat. Tech.
ISSN:2309-1185
Journal web link: http://www.jett.dormaj.com/

Assessment of Water Quality in Chandpur District of Bangladesh

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Received: 02/09/2013 Accepted: 31/10/2013 Published: 01/11/2013

Abstract

The study was conducted in Chandpur district of Bangladesh to assess the status of pond, supply and tube-well water quality parameters and identify water collection and distribution system. Twelve water quality parameters namely; pH, TDS, TS, SS, DO, COD, BOD, conductivity, hardness, chloride, arsenic and iron were analyzed according to standard laboratory method. The mean value of pH, TDS, TS, SS, DO, COD, BOD, conductivity, hardness and chloride for pond water of all upazilas were 7.41, 169 mg/l, 193.26 mg/l, 32.85 mg/l, 5.56 mg/l, 79.07 mg/l, 36.28 mg/l, 335.18 µs/cm, 86.15 ppm and 34.57 mg/l respectively. The mean value of pH, TDS, TS, SS, DO, COD, BOD, conductivity, hardness, chloride, iron, and arsenic for tube well water of all upazilas were 8.01, 111.81 mg/l, 122.36 mg/l, 5.58 mg/l, 46.98 mg/l, 14.81 mg/l, 249.17 µs/cm, 131.23 ppm 108.09 mg/l, 0.55mg/l and 0.078 mg/l respectively. The mean value of pH, TDS, TS, SS, DO, COD, BOD, conductivity, hardness, chloride and iron for supply water of all upazilas were 7.8, 133.42 mg/l, 155.03 mg/l, 6.19 mg/l, 66.56 mg/l, 17.13 mg/l, 248.19 µs/cm, 126.07 ppm 167.6 mg/l and 0.65 mg/l respectively. Study revealed that pond water quality was suitable in terms of pH, DO, TDS, TS, SS, chloride and hardness and not suitable in terms of COD, BOD and conductivity for different productive uses. Tube well water quality was in desired level in terms of pH, DO, TDS, TS, SS, chloride, iron and hardness and not suitable in terms of COD, BOD, conductivity, and arsenic for different productive uses. Supply water quality was in acceptable limits in terms of pH, TDS, TS, SS, chloride, iron and hardness and crossed acceptable limit in terms of COD, BOD, conductivity, and DO for different productive uses. It was found that all the parameters vary significantly with the types of water. Water quality management program should be initiated under supervision of government to maintain the acceptable limit and proper water supply scheme should be followed for effective water collection and distribution system.

Key words: Chemical parameter, collection, distribution, water quality, management

1. Introduction

Water is a very complicated and vitally important substance. It is the medium which gave birth to the first primitive living molecules and without it no life can exist [1]. Throughout history the quality and quantity of water available to man have been vital factors in asserting his well being [2]. Water is a chemical compound and may occur in a liquid form or in a gaseous form. All these three forms of water are extremely useful to man, providing the luxuries and comports, in addition to fulfilling his basic necessities of life [1]. Water is absolutely essential not only for survival of human beings, but also for animals, plants and all other living beings [1]. The great solvent power of water has been making the creation of absolutely pure water a theoretical rather than a practical goal. Even the highest quality distilled water is being is having dissolved gases and to a slight degree solids. The problem, therefore, has been one of the determining what quality of water has been required to meet a given purpose and then finding practical means of achieving that quality [3].

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The total water resources of the world amount to 26.6 trillion tons. Approximately 94.7% of this huge amount volume of water can occur in the lithosphere, its major parts being bound to minerals which constitute the rock bed [2]. Water resources are one of the most critical and valuable components of the resources of a nation [4]. Everyday water is needed for drinking and other household purposes. With marked rise in population the demand for pure water is gradually increasing. Still now, nearly two thirds of the population does not have reasonable access to safe and ample water supply [5]. The surface water resources continue to be contaminated with run-off water from agricultural fields, containing pesticides, fertilizers, soil particles, waste chemicals from industries and sewage from cities and rural areas. If the water is to be reused, it must be purified [6]. The quality of water is one of the vital concerns for mankind since it is directly linked with human welfare. It is a matter of history that fecal pollution of drinking water caused water-borne diseases which wiped out entire population of cities. At present, the menace of water-borne diseases and epidemics still looms large on the horizons of developing countries. Pollution of water is the culprit in all such cases [6]. There have been major developments in technology along with improved implementation and enhanced funding of pollution control

programs around the globe. Most important, the attitude of professionals and public has undergone radical shifts that reflect national demand and expectations for improved water quality. But unfortunately in the case of developing countries like Bangladesh; remarkable progress has not yet been made. It is serious for the surface water which includes pond water the important fresh water source of Bangladesh. Availability of water is a paradox. Water of usable quality and in adequate quantity is often not available. Many people in developing world do not have enough water for drinking, let alone for other uses [7]. But as the population increased, towns and cities developed and the habits of people improved. Trades and industries were established and as a result the demand for water increased considerably. The original small water sources became insufficient and large water sources became inevitable [8]. Water collection and distribution system is the important two elements for water resource management [9]. Distribution of water is done either by intermittent or continuous system. In the intermittent system, wastage of water may be controlled but the main disadvantage is that during non supply hours, water in pipe line rushes towards the lower reaches, thus creating partial vacuum in pipes, resulting in the sucking of impurities and gases in the pipeline. This may cause health hazards. Continuous supply, though preferable in every way, but cannot be functional in every town [1]. In early days, surface water was consumed by human beings for drinking, bathing, washing, etc. In those days man did not have the technical knowledge for purifying contaminated water. As a result, man had to suffer water-borne diseases like dysentery, cholera, etc. and innumerable village were destroyed by epidemics [8]. With the growth of civilization and development of towns or cities, man began to think over the issue of pure water for drinking, safety of life and healthy environment [8]. The distribution system plays an important role in the water supply scheme. Distribution should be done in such a way so that the water can be supplied evenly to the consumers and it can reach at every corner of various Zones [8]. Water pollution is every impact which changes the quality of our surface and subsoil waters to such a degree that its suitability either for human consumption or for the support of man's natural life processes with decrease or cease [1]. Water gets polluted if it has been not of sufficiently high quality to be suitable for the highest uses people wish to make of it at present or in the future [2].

1.1. Background of the study area

Chandpur district (Figure 1) is one of the most important districts in Bangladesh. About 2.6 million people live in this district. Most of the people live in the rural area. Population pressure is increasing day by day in this area. For this, water resource management has come into focus issue recently. Collection, distribution and quality status of water are three important tools for water resource management. The only dependable sources of water in Chandpur district are ground water and surface closed water like river, pond, lake etc. In most areas shallow tube wells provide turbid water which is not suitable for consumption. For drinking purpose only tube well water is used and for other purpose pond and river water is used in large scale. In urban area supply water also available for washing, bathing and drinking purposes. The population depends on river, pond, and tube well and supply water for all household and traditional uses. In this connection, it is essential to know the quality status of pond water, tube well water and supply water before using for various purposes. Observing these circumstances the present study was carried out to assess quality status of pond, tube well and supply water to prevent from further deterioration of pond, tube well and supply water quality in Chandpur district. The objectives of the present study were to assess the status of quality in pond, supply and tube-well water; identify the collection and distribution system of water in Chandpur district, and make a comprehensive evaluation of tube well, pond and supply water quality in Chandpur district of Bangladesh.

Figure 1: Study area map (Source: Banglapedia)

2. Materials and Methods

2.1. Chemicals and equipment used

The chemicals which were used for parameter test include KI and $MnSO_4$, concentrated H_2SO_4, stretch as indicator, $Na_2S_2O_3$ (0.005), Alkali-iodide-Azide, buffer solution. The equipment which were used for parameter test include pH meter, pipette, burette, conical flask, cylinder, beaker, filter paper, evaporating disk, desiccators, electrical balance, BOD bottle, COD incubator, hot plate etc.

2.2. Field collection and sample analysis in laboratory

Five ponds, five tube wells and three points for supply water have been selected randomly from every upazila (sub-district). After that five samples from pond, five

samples from tube well for each upazila and three supply water samples from selected three places of each upazila have collected and taken to laboratory. Total ninety one (91) samples were collected randomly from seven upazilas of Chandpur district in January 2010. Containers were thoroughly cleaned before use by distilled water. All samples were analyzed immediately in Department of Environment, Chittagong, Bangladesh to determine the pH , chemical oxygen demand (COD), biological oxygen demand (BOD), total solid (TS), total dissolved solid (TDS), suspended solid (SS), conductivity, hardness, dissolved oxygen (DO), chloride, iron (Fe) and arsenic (As). Water quality parameters were analyzed following standard analytical procedures.

2.3. Data analysis

All data were analyzed using MS excel and Duncan's Multiple Range Test (DMRT).

3. Results and discussion

3.1 Results

3.1.1 pH

The study revealed that quality of pond, tube-well and supply water vary significantly ($p \leq 0.05$) in terms of water pH. In pond water, highest (8.1) pH was found in Chandpur Sadar upazila. This may have due to excessive use of pond for different purposes. Soap, detergents and other washing material mixed with pond water and give alkaline value of pH. However, lowest (6.8) pH in pond water was found in Motlob upazila. This may have due to throwing of household wastes, decomposition of leaves, food materials and carried floating materials during storm runoff. pH mean value of pond water was highest (7.8) in Chandpur Sadar upazila and lowest (7.2) in Faridgonj upazila. pH mean value of pond water of Kauchua, Hazigonj, Shahrasti, Motlob and Haimchar upazila were 7.4, 7.3, 7.2, 7.3 and 7.4 respectively (Figure 2). In case of tube well water maximum (8.4) pH was detected in Haimchar Upazila and minimum (7.6) in Shahrasti upazila. The mean value of tube well water pH for Haimchar upazila was highest (8.3) and for Shahrasti upazila was lowest (6.8). The other mean value of tube well water for Kachua, Chandpur sadar, Motlob, Hazigonj, and Faridgonj upazila were 8.2, 8.0, 8.1, 7.9 and 8.0 respectively. The mean value of supply water for Shahrasti upazila was highest (8.0) and for Motlob upazila was lowest (7.6). The other mean value of supply water for Kachua, Chandpur sadar, Hazigonj, Faridgonj and Haimchar upazila were 7.7, 7.8, 7.9, 7.9 and 7.8 respectively. Figure 2 shows comparison of supply water, pond water, and tube well water pH among seven upazilas. The mean value of pond water pH for all upazilas of Chandpur district were 7.41 and tube well water 8.04 and supply water 7.84 respectively. pH levels of pond water (7.41) were suitable for bathing, washing or other productive uses according to EQSB (acceptable limit for productive uses is 6.5-8.3). pH levels of tube well water (8.01) were not suitable for drinking (acceptable level 7.0 to 7.5) bathing and washing according to Environmental quality standard of Bangladesh [10]. pH (7.8) levels of supply water were suitable for all productive uses. Figure 2 revealed that Shahrasti upazila shows the better water quality status than other upazilas in Chandpur district. Therefore, tube-well water quality status was deteriorated due to decomposing of waste, over use of ground water and many geological causes. For proper water resource management, it is needed to maintain the quality status of pond, tube well and supply water at productive level. pH value of pond water and supply water vary significantly ($p \leq 0.05$) in respect of different locations in the same upazila and tube well water not vary significantly ($p \leq 0.05$) in respect of different location in the same upazila.

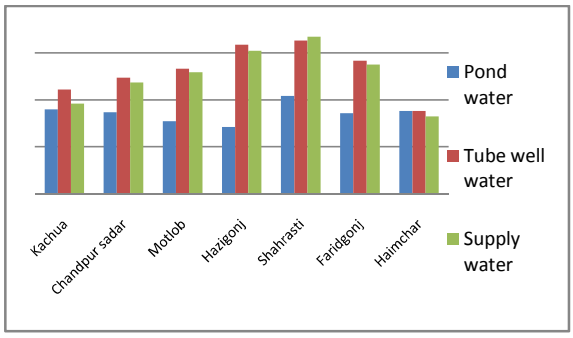

Figure 2: Comparison of supply water, pond water, and tube well water pH among seven upazilas of Chandpur district

3.1.2 Total Dissolved Solid (TDS)

TDS of water samples ranged from 130 mg/l to 220 mg/l. Highest TDS found in pond due to indiscriminate use of water for fish culture and dumping of waste. The mean value of pond water TDS was highest (198 mg/l) in Kachua and lowest (145.4 mg/l) in Faridgonj upazila. The mean value of pond water TDS for Chandpur sadar, Motlob, Hazigonj, Shahrasti and Haimchar upazila were 166 mg/l, 176mg/l, 170 mg/l and 150.2 mg/l and 177.4 mg/l respectively (Figure 3). In tube well water, highest (150.0 mg/l) TDS was found in Chandpur sadar, whereas, lowest (86.1.0 mg/l) in Haimchar upazila. The mean value of tube-well water TDS was highest (123.84 mg/l) in Chandpur sadar and lowest (97.03 mg/l) in Haimchar upazila. The other mean value of tube well water for Kachua, Motlob, Hazigonj, Shahrasti and Faridgonj upazila were 112.93 mg/l, 101.7 mg/l, 115.7 mg/l and 121.6 mg/l and 109.87 mg/l respectively (Figure 3). In supply water, highest (224.2 mg/l) TDS was observed in Chandpur sadar and lowest (84.2 mg/l) in Motlob upazila. The mean value of supply water TDS was highest (152.17 mg/l) in Faridgonj and lowest (104.97 mg/l) in Motlob upazila. The mean of TDS for Kachua, Chandpur sadar, Hazigonj, Shahrasti, and Haimchar upazila were 136.9 mg/l, 148.2 mg/l, 115.03 mg/l, 145.93 mg/l and 130.73 mg/l respectively. Figure 3 shows the comparison of supply, pond and tube-well water TDS among seven upazilas of Chandpur district. Study reveals that Shahrasti upazila shows better TDS level among other upazilas in Chandpur district. The lower TDS level indicates good water quality status and vice-versa. In the study area, tube well water revealed higher (111.81 mg/l) water quality compared to supply water (133.42 mg/l) and pond water (169.09 mg/l).

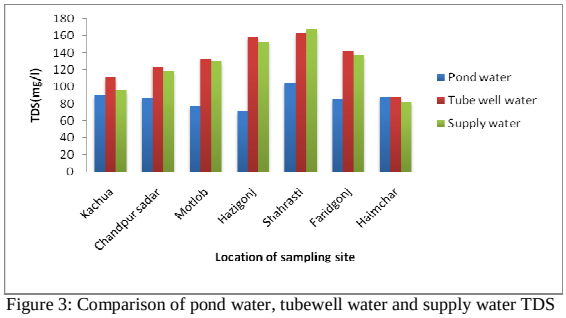

Figure 3: Comparison of pond water, tubewell water and supply water TDS among seven upazilas of Chandpur district.

3.1.3 Suspended Solid (SS)

The study revealed that pond, tube well and supply water quality vary significantly ($p \leq 0.05$) in terms of SS. In pond water, highest (57 mg/l) SS was found in Chandpur sadar, whereas, lowest (20 mg/l) in Faridgonj upazila. The mean value of pond water SS was found highest (45.6 mg/l) in Chandpur sadar and lowest (20 mg/l) in Faridgonj upazila. The mean value of pond water SS for Kachua, Motlob, Hazigonj, Faridgonj and Haimchar upazila were 37.6 mg/l, 31 mg/l, 29.3 mg/l, 28 mg/l and 33.3 mg/l respectively. In tube well water, highest (11 mg/l) SS was found in Motlob, on the other hand, lowest (4 mg/l) in Kachua upazila. The mean value of tube well water SS was found highest (9.4 mg/l) in Motlob and lowest (4.4 mg/l) in Hazigonj upazila. The mean value of tube well water SS for Chandpur sadar, Kachua, Shahrasti, Faridgonj and Haimchar were 7.4 mg/l, 5 mg/l, 6.6 mg/l, 5.8 mg/l and 5.2 mg/l respectively. In supply water, maximum (8 mg/l) SS was found in Chandpur sadar, whereas, lowest (1 mg/l) in Hazigonj upazila. The mean value of supply water SS was found highest (7mg/l) in Chandpur sadar and lowest (1mg/l) in Hazigonj upazila. The mean value of supply water SS for Kachua, Motlob, Shahrasti, Faridgonj and Haimchar were 6 mg/l, 2 mg/l, 4 mg/l, 6.10 mg/l and 6.17 mg/l respectively. Figure 4 shows the comparison of pond water, tube well water, and supply water SS among seven upazilas of Chandpur district. The mean value of pond water, tube well water and supply water of SS for all upazilas of Chandpur district were 32.85 mg/l, 6.25 mg/l and 3.7 mg/l respectively.

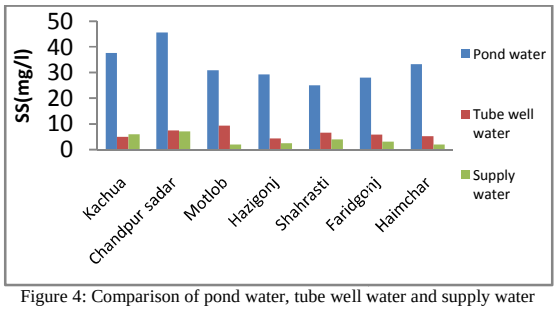

Figure 4: Comparison of pond water, tube well water and supply water among seven upazilas of Chandpur district.

3.1.4 Total Solid (TS)

In pond water, highest (232 mg/l) TS was found in Chandpur sadar and lowest (156.0 mg/l) in Shahrasti. The mean value for pond water TS was highest (232 mg/l) in Chandpur sadar and lowest (155.0 mg/l) in Shahrasti. The other mean value of pond water TS for Kachua, Motlob, Hazigonj, Faridgonj, and Haimchar Upazila were 209.09 mg/l, 205.67 mg/l, 183.50 mg/l, 160.26 mg/l, and 206.70 mg/l respectively. In tube well water, highest (157.6 mg/l) TS was found in Chandpur sadar and lowest (100.2 mg/l) in Haimchar. The mean value of tube well water TS was found highest (137.94 mg/l) in Chandpur Sadar and lowest (103.13 mg/l) in Haimchar. The other mean value of tube well water TS for Kachua, Motlob, Hazigonj, Shahrasti and Faridgonj were 123.47 mg/l, 116.6 mg/l, 122.4 mg/l, 123.93 mg/l and 134.02 mg/l respectively. In supply water, highest (231.1 mg/l) TS was found in Chandpur sadar and lowest (86.4 mg/l) in Motlob. Highest (200.67mg/l) mean value of TS was found in Kachua and lowest (124.76 mg/l) in Motlob. The other mean value of supply water TS for Chandpur sadar, Hazigonj, Shahrasti, Faridgonj and Haimchar were 193.93 mg/l, 141.5 mg/l, 164.26 mg/l, 172.93 mg/l and 155.03 mg/l respectively. The mean value of TS for all upazilas of pond water, tube well water, and supply water was 193.25 mg/l, 122.31 mg/l and 164.68 mg/l respectively. Highest TS level indicate deteriorated water quality and it may happen in pond water due to dumping of waste from near household. It may happen in supply water and tube well water due to underground impurities. In the study area tube well water quality was better than other types of water. Different types of factory like biscuit, soap, drug, salt and pesticides throw their wastes into near water bodies which cause higher TS value. The TS value of tube well water not vary significantly ($p \leq 0.05$) in terms of different locations in same upazila. But TS value of pond water and supply water vary significantly ($p \leq 0.05$) in terms of different location in the same upazila (Figure 5).

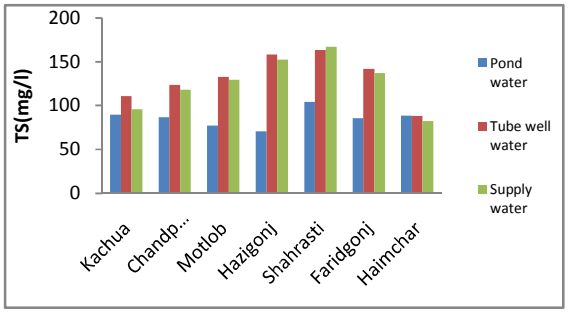

Figure 5: Comparison of supply water, pond water, tube well water TS among seven upazilas of Chandpur district.

3.1.5 Dissolved Oxygen (DO)

In pond water, highest (7.8 mg/l) DO was found in Kachua and lowest (3.2 mg/l) in Chandpur sadar. Moreover, the mean value for pond water DO was highest (6.6 mg/l) in Kachua and lowest (4.27 mg/l) in Chandpur sadar. The other mean value of DO for Motlob, Hazigonj, Shahrasti, Faridgonj and Haimchar were 5.8 mg/l, 5.66 mg/l, 5.8 mg/l, 5.52 mg/l, and 5.3 mg/l respectively. In tube well water, highest (6.9 mg/l) DO was found in Shahrasti, whereas, lowest (4.1 mg/l) in Haimchar. In addition, the

mean value of tube well water DO was found highest (6.6 mg/l) in Shahrasti and lowest (4.86 mg/l) in Haimchar. In supply water, highest (6.8 mg/l) DO was found in Hazigonj and lowest (5.4 mg/l) in Motlob. The mean value of supply water DO was found highest (6.6 mg/l) in Chandpur sadar and lowest (5.67 mg/l) in Shahrasti. The mean value of supply water DO for Kachua, Motlob, Hazigonj, Faridgonj, and Haimchar upazila were 6.4 mg/l, 5.87 mg/l, 6.5 mg/l, 6.1 mg/l, and 6.17 mg/l respectively. The mean value of DO for all upazilas of pond water, tube well water and supply water were 5.5 mg/l, 5.6 mg/l and 6.18 mg/l respectively. Figure 6 shows the comparison of supply water, pond water, tube well water DO among seven upazilas of Chandpur district. Lowest DO level indicates deteriorated water quality and it may happen in pond water due to decomposing of organic waste and excreta from feed items of fish. It may happen in supply water and tube well water due to underground impurities. In the study area tube well water was good for drinking but supply water (6.1 mg/l) crossed the limit (acceptable limit for productive uses 4-6 mg/l, EQSB). Pond water quality status was more deteriorated compared to tube-well and supply water. The DO level of pond, tube well and supply water vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila.

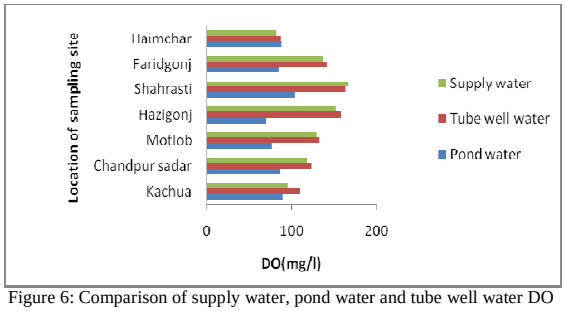

Figure 6: Comparison of supply water, pond water and tube well water DO among seven upazilas of Chandpur district.

3.1.6 Chemical Oxygen Demand (COD)

Study revealed that COD concentration ranged between 38.6 mg/l and 120.2 mg/l. In pond water, highest (120.2 mg/l) COD was found in Kachua and lowest (52.86 mg/l) in Haimchar upazila. Moreover, the mean value for pond water COD was highest (106.5 mg/l) in Kachua and lowest (62.75 mg/l) in Haimchar upazila. The other mean value for Chandpur Sadar, Motlob, Hazigonj, Shahrasti and Faridgonj were 73.67 mg/l, 67.86 mg/l, 78.47 mg/l, 71.44 mg/l, and 92.77 mg/l respectively. In tube well water, highest (97.3 mg/l) COD was found in Kachua and lowest (38.6 mg/l) in Hazigonj. The mean value of tube well water COD was found highest (64.67 mg/l) in Shahrasti and lowest (46.98 mg/l) in Haimchar upazila. The other mean value of COD for Kachua, Chandpur sadar, Motlob, Hazigonj and Faridgonj were 60.3 mg/l, 51.5 mg/l, 54.2 mg/l, 49.94 mg/l and 57.82 mg/l respectively (Figure 7). In case of supply water, highest (90.0 mg/l) COD was found in Chandpur sadar and lowest (60.1 mg/l) in Haimchar upazila. Highest (75.4 mg/l) mean value of supply water COD was found in Chandpur sadar and the lowest (58.20 mg/l) in Haimchar upazila. The mean value of supply water COD for Kachua, Motlob, Hazigonj, Shahrasti and Faridgonj were 68.9 mg/l, 70.2 mg/l, 64.2 mg/l, 61.2 mg/l and 67.8 mg/l respectively. The mean value for all upazilas of pond and tube well and supply water were 79.13 mg/l and 55.08 mg/l and 66.56 mg/l respectively. Figure 7 shows the comparison of supply water, pond water and tube well water COD among different upazilas of Chandpur district. Higher COD level (acceptable limit for productive uses according to EQSB is 4.0 mg/l) indicates deteriorated water quality. Different types of organic waste, inorganic waste, industrial wastes, suspended impurities and floating materials may induce higher COD level. It may happen in supply water and tube well water due to underground impurities. In the study area tube well water was better than pond and supply water. The COD level of pond and supply water vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila but tube well water not vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila.

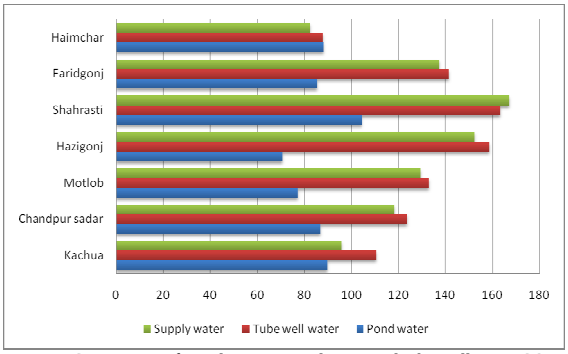

Figure 7: Comparison of supply water, pond water and tube well water COD among seven upazilas of Chandpur district.

3.1.7 Biological Oxygen Demand (BOD)

Study revealed that BOD varied from 4.2 mg/l to 60.20 mg/l. In pond water, highest (60.20 mg/l) BOD was found in Kachua and lowest (24.52 mg/l) in Haimchar upazila. The mean value of pond water BOD was highest (49.36 mg/l) in Kachua and lowest (28.38 mg/l) in Haimchar upazila. The other mean value for Chandpur Sadar, Motlob, Hazigonj, Shahrasti and Faridgonj were 35.60 mg/l, 33.10 mg/l, 39.20 mg/l, 34.50 mg/l and 33.80 mg/l respectively (Figure 8). In tube well water, highest (27.2 mg/l) BOD was found in Chandpur sadar and lowest (4.2 mg/l) in Haimchar. The mean value of tube well water BOD was found highest (23.23 mg/l) in Chandpur sadar and lowest (10.16 mg/l) in Haimchar. The other mean value of tube well water BOD for Kachua, Motlob, Hazigonj, Shahrasti and Faridgonj were 13.78 mg/l, 12.84 mg/l, 15.9 mg/l, 12.98 mg/l and 14.85 mg/l respectively (Figure 8). In supply water, highest (25.40 mg/l) BOD was found in Hazigonj and lowest (10.30 mg/l) in Faridgonj upazila. The mean value of supply water BOD was found highest (20.20 mg/l) in Hazigonj and lowest (14.9 mg/l) in Faridgonj upazila. The mean value of BOD for Kachua, Chandpur sadar, Motlob, Shahrasti and Haimchar were 18.2 mg/l, 16.46 mg/l, 15.60 mg/l, 15.40 mg/l and 19.20 mg/l

respectively. The mean value of BOD for all upazilas of pond, tube well and supply water were 36.28 mg/l, 14.81 mg/l and 17.13 mg/l respectively. Higher BOD level indicates deteriorated water quality. Dissolved minerals, decay of vegetation, aquatic growth, storm runoff, animal waste, fertilizer pesticides, irrigation return flows and open sanitation on the bank of pond also causes organic and inorganic load in the pond bottom which lower the BOD level. It may happen in supply water and tube well water due to underground impurities. In the study area, tube well water crossed the permissible limit (acceptable limit for drinking water according to EQSB, 0.2 mg/l) for drinking water. Supply and pond water were also crossed the desired limit for different productive uses. The BOD level of pond, tube well and supply water quality vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila.

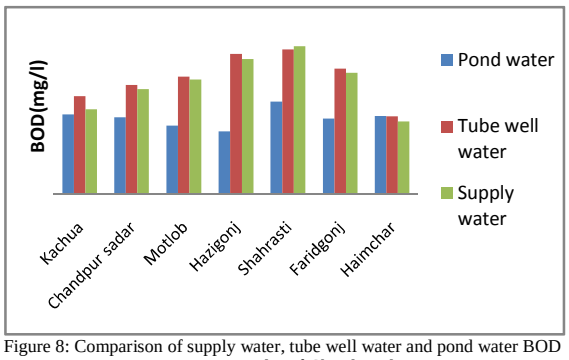

Figure 8: Comparison of supply water, tube well water and pond water BOD among seven upazilas of Chandpur district.

3.1.8 Conductivity

Conductivity in the study area was found to be varied from 116µs/cm to 536µs/cm. In pond water, highest (536 µs/cm) conductivity was found in Kachua and lowest (195 µs/cm) in Shahrasti upazila. The mean value for pond water conductivity was highest (432.40 µs/cm) in Kachua and lowest (232.40 µs/cm) in Shahrasti upazila. The other mean value for Chandpur sadar, Haimchar, Motlob, Hazigonj, and Faridgonj upazila were 353.53µs/cm, 319.33µs/cm, 402.29µs/cm, 346.00µs/cm, and 260.27µs/cm respectively (Figure 9). In tube well water, highest (316µs/cm) conductivity was found in Motlob and lowest (116.0µs/cm) in Hazigonj upazila. The mean value of tube well water conductivity was found highest (301.64 µs/cm) in Motlob and lowest (201.62µs/cm) in Hazigonj upazila. The other mean value of conductivity for Kachua, Chandpur sadar, Shahrasti, Faridgonj and Haimchar upazila were 256.64 µs/cm, 275.02 µs/cm, 250.38 µs/cm, 233.78 µs/cm and 225.4µs/cm respectively (Figure 9). In supply water, highest (315µs/cm) conductivity was found in Kachua and lowest (170µs/cm) in Motlob upazila. The mean value of supply water conductivity was found highest (305µs/cm) in Kachua and lowest (202 µs/cm) in Motlob upazila. The mean value of supply water conductivity for Chandpur sadar, Hazigonj, Shahrasti, Faridgonj and Haimchar were 262µs/cm, 241µs/cm, 277µs/cm, 217µs/cm and 233µs/cm. The mean value of conductivity for all upazilas of pond, tube well and supply water were 335.17µs/cm, 249.17µs/cm and 248.19µs/cm respectively. Higher conductivity level indicates deteriorated water quality. Dissolved minerals, storm runoff, animal waste, fertilizer pesticides, irrigation return flows, leaching from bottom deposits and household uses increase conductivity level. It may happen in supply water and tube well water due to underground impurities. The acceptable limit of conductivity for drinking water is 4.7-5.8 µs/cm, for livestock 8-10 µs/cm. In the study area, tube well water crossed the permissible limit for drinking water. Supply and pond water quality were also crossed the desired limit for different productive uses. Therefore, all types of water quality status were not good in terms of conductivity. The conductivity level of pond and tube well water were not vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila.

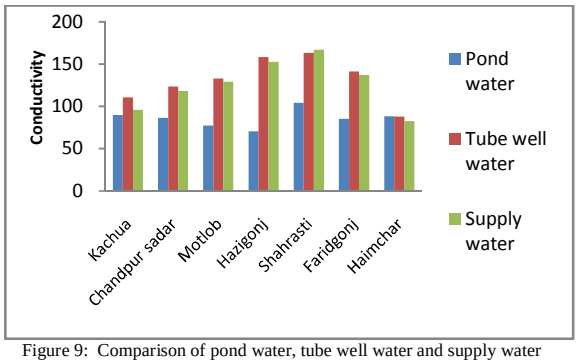

Figure 9: Comparison of pond water, tube well water and supply water conductivity among seven upazilas of Chandpur district.

3.1.9 Hardness

In pond water, highest (110.20 ppm) hardness was found in Shahrasti and lowest (68.20 ppm) in Hazigonj upazila. The mean value for pond water hardness was highest (104.30 ppm) in Shahrasti and lowest (70.86 ppm) in Hazigonj upazila. The other mean value of pond water hardness for Haimchar, Motlob, Faridgonj, Kachua and Chandpur sadar upazila were 88.32 ppm, 77.42 ppm, 85.54 ppm, 89.90 ppm, and 86.70 ppm respectively (Figure 10). In tube well water, highest (275.0 ppm) hardness was found in Shahrasti and lowest (45 ppm) in Haimchar upazila. The mean value of tube well water hardness was found highest (163 ppm) in Shahrasti and lowest (88 ppm) in Haimchar upazila. The other mean value of tube well water hardness for Kachua, Chandpur sadar, Motlob, Hazigonj and Faridgonj upazila were 110.68 ppm, 123.54 ppm, 132.94 ppm, 158.52 ppm and 141.60 ppm respectively (Figure 10). In supply water, highest (174 ppm) hardness was found in Shahrasti and lowest (63.7 ppm) in Haimchar upazila. The mean value of hardness was found highest (167.06 ppm) in Shahrasti and lowest (82.40 ppm) in Haimchar upazila. The mean value of hardness for Kachua, Chandpur sadar, Motlob, Hazigonj and Faridgonj were 97.87 ppm, 118.30 ppm, 129.27 ppm, 152.40 ppm and 137.20 ppm respectively. The mean value of hardness for all upazilas of pond water, tube well water and supply water were 86.14 ppm, 131.23 ppm and 126.07 ppm respectively. Figure 10 shows the comparison of supply, pond and tube well water hardness among different upazilas of Chandpur district. Higher hardness level indicates deteriorated water quality.

Carbonate and bicarbonate of calcium, sulfate of magnesium and chlorides may increase hardness level. It may happen in supply water and tube well water due to underground impurities. In the study area, tube well water quality was not crossed the permissible limit for drinking water standard (WHO). Supply and pond water were also not crossed the desired limit for different productive uses. Therefore tube well water quality status was in acceptable limit and pond and supply water were also the acceptable limit for productive uses in terms of hardness. The hardness level of pond, tube well and supply water were vary significantly ($p \leq 0.05$) in terms of different locations in the same upazila.

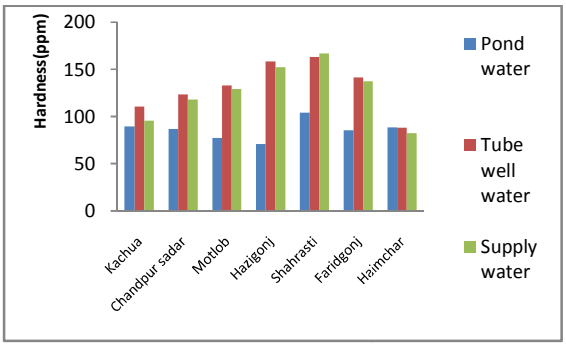

Figure 10: Comparison of pond water, tube well water and supply water hardness among seven upazilas of Chandpur district.

3.1.10 Arsenic

The study revealed that tube well water quality vary significantly ($p \leq 0.05$) in terms of arsenic. In tube well water, highest (0.13 mg/l) arsenic was found in Shahrasti and lowest (0.03 mg/l) in Motlob upazila. The mean value of arsenic was found highest (0.1 mg/l) in Shahrasti and lowest (0.05 mg/l) in Motlob upazila. The mean value of arsenic for Kachua, Chandpur sadar, Hazigonj, Faridgonj and Haimchar were 0.086 mg/l, 0.09 mg/l, 0.05 mg/l, 0.09 mg/l and 0.08 mg/l respectively (Figure 11). The average value of arsenic of all upazilas in Chandpur district was 0.078mg/l, which indicates that the tube well water is not suitable for drinking according to EQSB (acceptable limit for drinking is 0.05 mg/l). Arsenic value of tube well water vary significant ($p<.05$) in the respect of different locations in the same upazila.

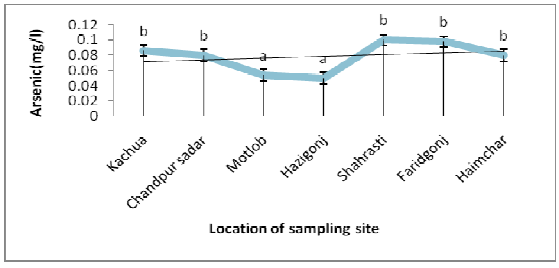

Figure 11: Arsenic concentration in tube well water in seven upazilas of Chandpur district.

Notes: *Values in the graph followed by the same letter are not significantly different ($p<.05$) according to Duncan's Multiple Range Test (DMRT).

3.1.11 Fe^{2+} /Fe^{3+}

It was found that tube well and supply water quality vary significantly ($p \leq 0.05$) in terms of iron. In tube well water, highest (1.80mg/l) iron concentration was found in Kachua and lowest (0.1mg/l) in Hazigonj upazila. The mean value of Fe in tube well water was found highest (1.3mg/l) in Kachua and lowest (0.2mg/l) in Hazigonj upazila. The mean value of Fe for Chandpur sadar, Motlob, Shahrasti, Faridgonj and Haimchar were 0.72mg/l, 0.34mg/l, 0.52mg/l, 0.46mg/l and 0.3mg/l respectively. In supply water, highest (1.80 mg/l) and lowest (0.1 mg/l) Fe were found in Shahrasti and Motlob upazila respectively. The mean value of Fe in supply water was found highest (1.16mg/l) in Shahrasti and lowest (0.2mg/l) in Motlob upazila. The mean value of Fe for Kachua, Chandpur sadar, Hazigonj, Faridgonj and Haimchar upazila were 0.6 mg/l, 0.3 mg/l, 0.7 mg/l, 0.46 mg/l and 0.9 mg/l respectively. Figure 12 shows the comparison of Fe between tube well water and supply water among seven upazilas of Chandpur district. The average value of Fe in tube well water and supply water for all upazilas in Chandpur district were 0.55 mg/l and 0.65 mg/l respectively. The Fe level both tube-well water and supply water were suitable for drinking and different uses according to EQSB (acceptable limit for drinking is 1mg/l). The value of Fe of tube well water and supply water vary significant ($p<.05$) in the respect of different locations in the same upazila.

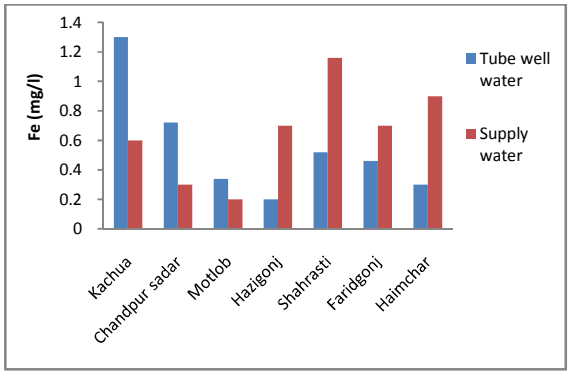

Figure 12: Comparison of tube well water and supply water iron among seven upazilas of Chandpur district.

3.1.12 Chloride

Chloride concentration in the study area was found to be varied from 52 mg/l to 220 mg/l. In tube well water, maximum (185 mg/l) concentration of chloride was found in Motlob and minimum (52 mg/l) in Hazigonj upazila. Highest (175.0 mg/l) mean value of chloride was found in Motlob and lowest (68.8 mg/l) in Hazigonj upazila. The mean value of chloride in tube well water for Kachua, Chandpur sadar, Shahrasti, Faridgonj and Haimchar upazila were 88.4 mg/l, 122.4 mg/l, 110.2 mg/l, 108.2 mg/l and 83.6 mg/l respectively. In supply water, highest (220 mg/l

concentration of chloride was found in Motlob and lowest (112 mg/l) in Kachua upazila. The mean value of chloride in supply water was found highest (201.0 mg/l) in Motlob and lowest (120.67 mg/l) in Kachua upazila. The mean value of supply water chloride for Chandpur sadar, Hazigonj, Shahrasti, Faridgonj and Haimchar upazila were 146.67 mg/l, 166.67 mg/l, 186.6 mg/l, 188.3 mg/l and 163.3 mg/l respectively. In pond water, maximum (60 mg/l) chloride was found in Chandpur sadar and minimum (15 mg/l) in Motlob upazila. Highest (49.8 mg/l) mean value of chloride was found in Chandpur sadar and the lowest (26.8 mg/l) in Shahrasti upazila. The mean value of chloride for Kachua, Motlob, Hazigonj, Faridgonj and Haimchar were 30 mg/l, 27.2 mg/l, 31.6 mg/l, 29.6 mg/l and 47 mg/l respectively (Figure 13).

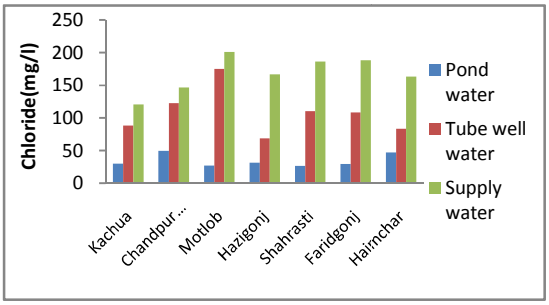

Figure 13: Comparison of pond water, tube well water and supply water chloride among seven upazilas of Chandpur district.

3.1.12 Water quality status in Chandpur district

The standard value of pH for productive uses is 6.5-8.3 [10] and for drinking purpose is 7.0-7.45 (WHO). The standard value of TDS for drinking and other productive uses is 500 mg/l [11]. The standard value of TS for drinking and other productive uses is 1000 mg/l [11]. The standard value of SS for bathing purposes is 150 mg/l [12]. The standard value of COD for drinking and other productive uses is 4.0mg/l [10]. The standard value of BOD for drinking is 0.2 mg/l [10] and for productive uses is 0.2-10 mg/l [11]. The standard value of DO for drinking and other productive uses is 4-6 mg/l [10]. The standard value of conductivity for drinking is 4.5-5.8 µs/cm and for other purpose is 8-10 µs/cm (EPA). The standard value of hardness for drinking and other productive uses is 200 ppm [11]. The standard value of chloride for drinking and productive purposes is 600 mg/l [11]. The standard value of arsenic for inland surface water and tube well water is 0.2 mg/l and 0.05 mg/l [10]. The standard value of Iron for drinking water purposes is 2 mg/l [10].

Figure 14 shows the overall water quality parameter status of Chandpur district. In the present study, it was found that pond water quality was suitable in terms of pH, DO, TDS, TS, SS, Chloride and hardness and not suitable in terms of COD, BOD and conductivity for different productive uses. Tube well water quality was desired level in terms of pH, DO, TDS, TS, SS, Chloride, Iron and hardness and not suitable in terms of COD, BOD, conductivity, and Arsenic for different productive uses. Supply water quality was acceptable limits in terms of pH, TDS, TS, SS, Chloride, Iron and hardness and crossed acceptable limit in terms of COD, BOD, conductivity, and DO for different productive uses.

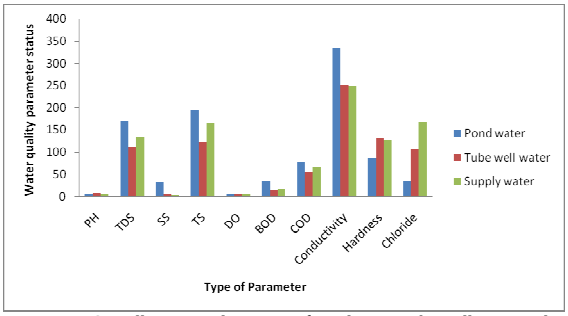

Figure 14: Overall water quality status of pond water, tube well water and supply water in Chandpur district.

3.1.13 Collection and distribution system of water in Chandpur District

In the study area, it was found that in every upazila of Chandpur district a comprehensive distribution system of water exists. The distribution system is controlled by Pourashava water supply section (PWSS) and technologically and financially supported by department of public health and engineering (DPHE). For distribution of water to the consumer's taps, pumping system with storage followed. In this system the excess of water pumped during periods of low consumption was stored in elevated tank. At the time of high consumption the stored water in the elevated tanks augments the pumping and peak demand is fulfilled. Pumps have not to be run at varying speeds but at constant speed, thus reducing the wear of pumps. There are four methods of laying distribution pipes in a locality. In Chandpur town, dead end system was followed for distribution of water. There are three elevated tanks (capacity 66000 gallon) in Chandpur town for water distribution purpose which are situated in Rampur, college road and academy. PWSS supply water to the household, government or non government institutions and industry etc. Water supplied to the consumers in Chandpur Town by intermittent supply system. For distribution purpose water was collected from underground sources. The method of collecting water from surfaces sources for the water supply scheme is termed as intake. But this type of collection system did not exist in the study area. Supply water sometimes contains turbid, bad smell and too much iron contains water. In the end point of pumps need to be wash per one month but it was not maintain in the study area and due to this fault different impurities comes to consumer's tap. Leakages of pumps also causes turbid and bed smell water supply to consumer tape.

3.2 Discussions

The study reveals that mean value of Chandpur district pond water pH, TDS, SS, TS, DO, COD, BOD, conductivity, and hardness were 7.41, 169.0 mg/l, 32.85 mg/l, 193.26 mg/l, 5.57 mg/l, 79.06 mg/l, 36.28 mg/l, 335.17µs/cm, and 86.15ppm respectively. The mean value of Chandpur district tube well water pH, TDS, SS, TS, DO, COD, BOD, conductivity, hardness, chloride, arsenic and iron were 8.01, 111.8mg/l, 6.25mg/l, 122.36mg/l, 5.58mg/l,

55.05mg/l, 14.81mg/l, 249.17µs/cm, 131.23ppm, 108.09 mg/l and 0.55mg/l respectively. The present study also revealed that mean value of Chandpur district supply water pH, TDS, SS, TS, DO, COD, BOD, conductivity, hardness, iron and chloride were 7.45, 133.42 mg/l, 3.7mg/l, 164.64 mg/l, 6.19 mg/l, 66.56 mg/l, 17.13 mg/l, 248.19 µs/cm 126.07 ppm, 167.6mg/l, and 0.65mg/l respectively.

A study reveals that mean values of parameters were conductivity 84–805 μscm^{-1}; DO: dry-5.52 mg/l, monsoon-5.72 mg/l; BOD: dry-1mg/l, monsoon-0.878 mg/l; Total Solid: dry-149.4 mg/l, monsoon-145.7 mg/l. Although the phosphate concentration has been found within the limit set by DOE for fishing, irrigation and recreational purposes, however ammonia nitrogen has been found to exceed the limit [13]. A study reveals that the mean values of water temperature, TSS, TDS, TS, turbidity, DO, BOD, COD, pH, conductivity and total alkalinity were 23^0C, 365.87 mg/l, 8018.8 mg/l, 8518.33 mg/l, 31.54 FTU, 1.55 mg/l, 6.65 mg/l, 13961 µs/cm, 247.47 mg/l, 560.27 mg/l and 4.8 mg/l respectively [14].

Another study reveals that the mean values of SS in pond, tube well and supply water are 497 mg/l, 9 mg/l and 99.21 mg/l respectively [15]. Total hardness has found 132.5 mg/l as a mean value in one studies [15] whereas, it has found 49-61 mg/l in another study [16]. A study on the pond water quality of Chittagong University shows that average pH 6.18 [17]. Another study revealed that the highest pH of Chittagong city area was 7.17 and the lowest was 5.59 with the mean value of 6.56 [15]. A study reveals that in rainy season DO varied from 7.15 mg/l to 8.26 mg/l and COD from 15 mg/l to 75 mg/l and in dry season their concentration varied from 6.65 mg/l to 7.66 mg/l and 8 mg/l to 48 mg/l, respectively [18].

4. Conclusions and recommendations

4.1 Conclusions

The water quality parameters of pH, TDS, SS, TS, COD, BOD, DO, conductivity, hardness, iron, chloride and arsenic were varied significantly ($p \leq 0.05$) among sampling sites and also varied significantly ($p \leq 0.05$) among pond, tube well and supply water. Water quality status was comparatively better in tube well water. Because tube well water comes from underground sources which have less chance to mixed suspended impurities, dissolved impurities, floating impurities and natural induce pollutants. But the pond water quality status was deteriorated due to its indiscriminate uses like washing of cattle's, utensils and patients dirty clothes, dumping of household wastes, decay of vegetation, animal wastes, fertilizer pesticides, irrigation and fish culture. Supply water quality status was also deteriorated due to poor maintenance of collection and distribution system. It is mentioned here that, only these parameters can not make water suitable for domestic uses as biological parameters as well the other physical and chemical are important factors for drinking as well as other uses of water. For the proper water resource management the existing water bodies have to be protected from all types of pollution and water quality parameters have to be maintained acceptable limit of EQSB for different productive uses. Water collection and distribution system are another two important tools for proper water resource management. In Chandpur district, a comprehensive collection and distribution system followed under supervision of Paraushava water supply section (PWSS).

4.2 Recommendations

It may recommended that necessary steps and care should be taken by the concerned authority immediately to the maintenance of pond, tube well and supply water quality status and for the proper collection and distribution system of Chandpur district. The following recommendations are suggested:

1. The drinking water sources and it's nearby area should be kept clean and regular cleaning be done.
2. Stop the practice of dumping waste into the nearby water bodies.
3. Fish culture should be done in a demarcated area and use different chemicals and feed items with appropriate doses.
4. Chemicals such as potassium permanganate are spread regularly in order to protect water from microorganism's contamination.
5. Use of pesticides in agriculture should be limited and only standard quality pesticides be used.
6. Seepage pits, refuse dumps, septic tanks, transport and with diverse agricultural, chemical or biological pollutants should be maintained appropriately so that ground water cannot be polluted.
7. Regular monitor the samples of underground water at different depth of suspected areas and find out the leakages of water supply pumps and wash the pumps at least one per month.
8. Pesticides, fertilizers and organic compounds also tend to enter the water table through percolation, so it should be controlled by appropriate management technique.
9. Water works engineers should detect the possible causes of contamination of water sources and also take appropriate action to minimize the problems.
10. The government needs to give special attention for proper water resource management and take comprehensive water quality management program and more researches on water quality, collection and distribution system are to be initiated.

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