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Suitability Assessment of Water Quality of Assabol Dam for Irrigation, Fish Culture and Drinking Purposes at Erob Wereda, Eastern Tigray; Ethiopia

Shifare Berhe[a], Seyoum Leta[b]

a Department of Chemistry, College of Natural and Computational Science, Jigjiga University P.O.Box: 1020, Jigjiga,Ethiopia, Email: shifare7@gmail.com

[b] Center for Environmental Science, College of Natural Science, Addis Ababa University, P.O.Box: 33348, Addis Ababa, Ethiopia, Email: Seyoum.leta@aau.edu.et

Abstract: ***The present study aimed at assessing the suitability of Assabol flood water harvesting dam for irrigation, fish culture and drinking purposes by evaluating its physical, chemical and bacteriological qualities and selected heavy metals (Co, Cd, Pb, Cu and Zn) concentrations. Composite surface water samples in triplicates were collected from the dam at various sampling points and analyzed using standard methods. The laboratory results of this study revealed that total hardness(182.8±0.20, 189.8±0.25, 193.8±0.36 mg/l), ammonium (0.31±0.02, 0.37± 0.01, 0.38 ±0.01 mg/l), alkalinity(135.2±0.28, 140.77±0.25, 140.93 ± 0.81 mg/l) and total coliform ($2.1x10^5$, $2.06x10^5$, $2.20x10^5$ CFU/1000ml) as well as lead, (0.078±0.03, 0.07±0.01, 0.078±0.02 mg/l) concentration for the sample sites AS_1, AS_2 and AS_3 respectively exceeds the permissible limit of WHO standards for drinking purpose. Results of analyzed irrigation parameters such as , Sodium Adsorption Ratio(0.46,±0.02,0.48±0.01, 0.04±0.06meq/l); Residual Sodium Carbonate (-1.35±0.03, -0.75±0.05, -0.72±0.041meq/l); Electrical Conductivity(490.2±0.31, 482.10 ± 0.12, 523.33 ± 0.29μs/cm) and specific ion toxicity(Na%, 15.3±0.01, 17±0.03, 17.3± 0.02; Cl^-, 2.19±0.13, 2.2±0.04, 2.34±0. 03meq/l) including (PH , 7.8±0.10, 8.10 ± 0.21, 7.9±0.11; HCO_3-, 2.6±0.01, 2.95±0.04, 2.93+0.02 meq/l) for the three sites respectively were also found to be within maximum permissible limit of FAO 1985. Chloride concentration might be toxic to Cl^- sensitive crops even if its values lie within the range of permissible limit. The concentrations of heavy metals fall within allowable limit of FAO1985 except Cu concentration. Similarly, physical, chemical and bacteriological parameters of Assabol flood water harvesting Dam found to be within a permissible limit indicating its suitability for aquaculture activities. The findings from this study revealed that Assabol flood harvesting Dam water need proper treatment before it is used for drinking and irrigation purposes, while the water is safe for fish culture activities. The study also shows there is a need for watershed management, regular surveillance and water quality monitoring for the safe and sustainable use of the dam water resource in the locality.***

Keywords: Assabol flood water harvesting Dam, irrigation, drinking, fish aquaculture

Corresponding Author: Shifare Berhe, Email: shifare7@gmail.com

1. Introduction

Surface water generally available in rivers, tanks, ponds, and dams is used for drinking, irrigation, fisheries and power supply, etc. Now a day"s fresh water has become a scare commodity due to over exploitation and pollution (Singh and Mathur, 2005). Water quality is the characteristics of a water supply that will influence its suitability for specific use i.e. how well the quality meets the needs of the user. Water quality often declines as result of increased anthropogenic activities such as intense land and water uses; increased urbanization, industry and tourism activities. Uncontrolled and excessive use of fertilizers and pesticides in agriculture has long-term effects on ground and surface water resources (Bedelu Amare, 2005). Proper management of ground and surface water resources requires baseline water quality information as well as routine surveillance and monitoring. . The purpose of the present study was to generate baseline water quality information on the Assabol flood water harvesting dam in order to evaluate its suitability for irrigation, drinking and aquaculture activities by the nearby and downstream communities in line with WHO and FAO standards and guidelines.

2. Materials and Methods

2.1 Description of Study Area

The Assabol flood water harvesting Dam is found in Erob Wereda, which is located between 14° 7" to 14° 10" N latitude and 39 °30" to 40°00" E longitude in the north-eastern part of Tigray regional state of Ethiopia (about 150 km north of Mekelle, the capital of the Tigray Region) (Fig. 1). It is located in the far north of Ethiopia bordered by Eritrea from the north and the Afar Region from the east (CSA, 2011). Since 1995 the rainfall in the Wereda is highly erratic and variable across time and space. This makes the people of the Wereda vulnerable to chronic famine where people in the area depend on external food aid from year to year given by humanitarian organizations. The construction of floodwater harvesting scheme was considered the best alternative solution for solving the water scarcity problem of Erob Wereda.

One of this floodwater harvesting scheme was the Assabol dam constructed by Adigrat Diocese Development Action (ADDA) project with construction duration of 14 years (1996-2010) having the water holding capacity of 1 million m^3 and 40 meters height. The Dam was constructed with the support of Arthur Waser Foundation, Swizerland with a total cost of 15 million Birr (Andres Strebel, 2007). The dam holds and store a part of the flood runoff water from the watershed

in the rainy season and people in the locality uses water from this Dam for the rest of the year for irrigation and for supplying drinking water as well as other purposes.

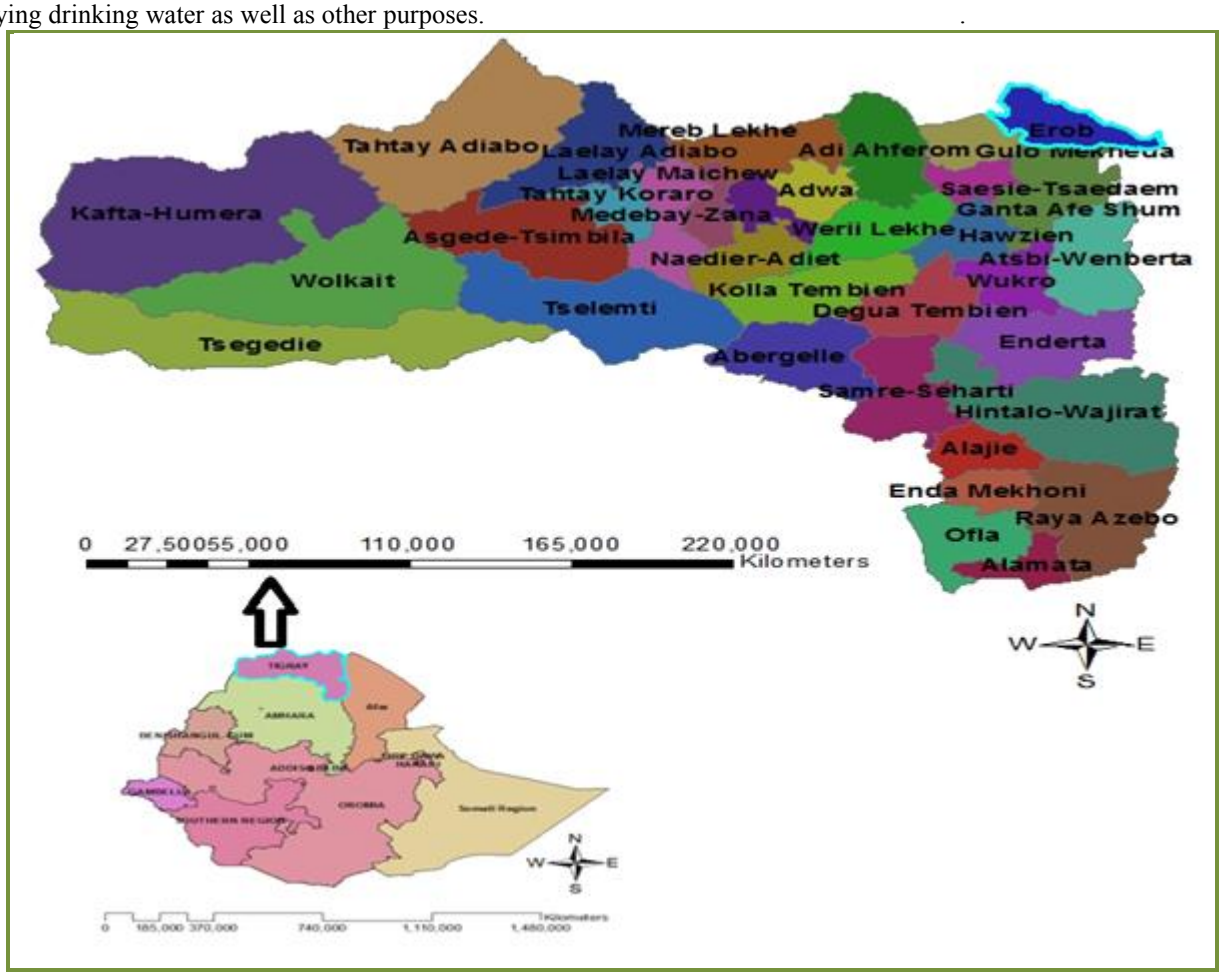

Figure 1: Erob Wereda in Tigray Regional State of Ethiopia

2.2 Sample and Sample Collection

2.2.1 Water sample collection

A total of three composite water samples were collected from three sites of the Dam in 1L bottles three times in the month of December 2014. The three sampling points were denoted as AS_1, AS_2 and AS_3 for samples collected from two irrigation canals (canals-1&-2) and Dam where the community utilizes the water for irrigation, drinking, bathing and washing clothes. Water samples from each three sampling sites were collected by direct immersion of bottles on water sample points handled by rope and preserved following standard methods (APHA, 1998). Sampling bottles were washed with concentrated nitric acid and distilled water to avoid contamination prior to sample collection. Bottles were preserved using icebox and transported to Geochemistry Laboratory and Aquatic Chemistry Laboratory of Mekelle University for physical, chemical and bacteriological water quality parameters analyses and Ezana Analytical Laboratory Plc for heavy metal analysis with in 5hrs after sample collection.

2.2.2 Sediment sample collection

Composite sample from surface sediments of Assabol flood harvesting Dam were also collected from the sampling locations of AS_3. A total of 300 grams of sediments were taken from the bottom of the river with depth of 0-15cm using a hand held polyethylene scoop. After the sediment samples were transferred to polyethylene plastic bags the samples were stored frozen in icebox and taken to laboratory for heavy metal determination. Sediment samples were not taken from sample sites AS_1 and AS_2 since these sites are irrigation canals.

2.3 Analysis of Water and Sediment Samples

2.3.1 Physical and chemical analyses

Analyses of physical parameter for water samples such as turbidity, temperature, pH, electrical conductivity, and total dissolved solids were conducted in situ. Turbidity and PH of collected water samples were measured using Digital Turbidity Meteric2100A instrument and PH meter (PH013) respectively. Temperature and EC were measured by using a portable HACH conductivity meter (Wagtech125408, UK). All the instruments were calibrated prior to taking readings from the three sample locations (AS_1, AS_2 & AS_3). Chemical parameters such as Alkalinity, Total hardness, Calcium, Magnesium, Chloride, Carbonates and Bicarbonates were analyzed according to standard methods (APHA, 1998). Potassium and sodium determination were carried out by flame photometer (Sherwood369,UK). Ammonium, nitrate,

nitrite, sulfate and phosphate concentration were analyzed using UV-Visible Spectrophotometer (LAMBDAEZ201, USA). BOD of the sample was determined through dilution Method following procedures as described in APHA (1998). Residual Sodium Carbonate, RSC and Sodium Adsorption Ratio, SAR values of the water samples were also estimated from the obtained values of calcium, magnesium sodium, carbonate and bicarbonate using mathematical formulas described in FAO 1985 guideline.

2.3.2 Microbial analysis

The water samples of the Dam were also analyzed for *Total Coliform (TC) and Fecal Coliforms (FC)* using the membrane filter technique following standard methods (APHA, 1998).

2.3.3 Heavy Metal Analysis

Similarly the concentration of some selected heavy metals (Pb, Cu, Cd, Co, Zn) in both water and sediment samples were measured after digestion using Graphite Furnace Atomic Absorption spectrometer(AA74D2) following standard methods APH(1998). The reagent used for all analysis was Analytical Reagent grade and double distilled water was used for preparation of solutions. Finally, obtained data was statistically evaluated by using Orgin6.0 software.

3. Results and Discussion

3.1 Suitability of Assabol Dam Water for Drinking Purpose

The physical, chemical and bacteriological water quality of the Assabol Dam is presented in Table 1 below. Temperature of Assabol Dam water varies from 19.7±0.03 ^{o}C at sample site AS_1 to about 20.5±0.02 ^{o}C at sample site AS_2. This range fits within permissible limit of WHO for drinking purpose. As shown in Table-1, the mean pH values of Assabol dam water vary from neutral (7.8±0.10) to slightly alkaline (8.10± 0.21) which lies within the WHO permissible limit (6.5-8.5).

Table 1: Physical-chemical and bacteriological water qualities of Assabol Dam Water (n=3).

Parameters	*AS_1*	*AS_2*	*AS_3*	*WHO standards (2012) for drinking*
Temperature(C^0)	19.7±0.03	20.5±0.02	20±0.01	<25C^0
Total hardness	182.8±0.20	189.8± 0.25	193.8±0.36	<100mg/l
Ammonium(mg/l)	0.31±0.02	0.37± 0.01	0.38 ±0.01	<0.2 mg/l
Total dissolved solids	392.3±0.04	385.60 ± 0.06	418.67±0.23	<500mg/l
E.Conductivity (µs/cm)	490.2±0.30	482.10 ± 0.12	523.33 ± 0.29	400-800
PH	7.8±0.10	8.10 ± 0.21	7.9±0.10	6.5-8.5
Sodium(mg/l)	14.7±0.20	15.8± 0.20	15.03±0.15	<100mg/l
Potassium(mg/l)	1.67±0.02	1.83±0.04	1.80±0.02	<150 mg/l
Calcium(mg/l)	61±0.20	54.10±0.16	62.03±0.25	<75 mg/l
Magnesium(mg/l)	12.1±0.31	12.4±0.10	13.033±0.25	<125mg/l
Chloride (mg/l)	79±0.23	78.83±0.15	83.23 ±0.30	<250mg/l
Nitrate(mg/l)	7.88±0.03	7.61±0.29	8.13±0.01	<45mg/l
Nitrite (mg/l)	0.023±0.01	0.015±0.01	0.01667±0.02	-
Alkalinity(mg/l)	135.2±0.28	140.77±0.25	140.93 ± 0.81	<75mg/l
Carbonate (mg/l)	1.33±0.01	1.95±0.04	1.847+0.02	-
Bicarbonate (mg/l)	161.8±0.21	180±0.05	182.034±0.30	-
Sulphate (mg/l)	113.6±0.42	101.4±0.26	113.57±0.21	<250
Phosphate (mg/l)	1.76±0.02	1.64±0.015	1.69± 0.02	-
T. coli form per 1ml	210±0.05	206 ±0.25	220±1.0	0
Turbidity(NTU)	3.52±0.14	3.78±0.08	4.27± 0.300	<5NTU
BOD	1.85±0.04	1.68±0.05	1.83± 0.01	<4

ND= not detected

Table 2: Heavy metals concentrations in the water samples from Assabol Dam (n=3).

Heavy metals	*AS_1*	*AS_2*	*AS_3*	*WHO(2012 drinking purpose(mg/l)*	*FAO 1985 (Irrigation)*
Cobalt(Co)	0.023±0.006	0.038±0.02	0.03±0.02	-	0.05
Cadmium(Cd)	ND	ND	ND	0.003	0.01
Lead (Pb)	0.078±0.003	0.07±0.01	0.078±0.02	0.01	5
Cupper(Cu)	0.293±0.01	0.337±0.04	0.21±0.04	2	0.2
Zinc(Zn)	0.467±0.04	0.587±0.03	0.52±0.02	3	2

ND = not detected

Table 3: Heavy metal content of the sediment sample from Assbol Dam (n=3)

Heavy metals	*Sediment sample*	*EPA(mg/kg) (drinking)*	*ISQD (irrigation)*
Cobalt(Co)	15.88±0.10	-	40
Cadmium(Cd)	ND	-	0.6
Lead (Pb)	5.957±0.14	128	35
Cupper(Cu)	32.00±0.06	149	35.7
Zinc(Zn)	53.69±0.17	459	123

ISQDs = Interim freshwater Sediment Quality Guidelines

The mean values of electrical conductivity of Assabol Dam ranged from 482.10µs/cm to 523.33(Table-1). Conductivity is an important criterion in determining the suitability of water for irrigation (Clesceri, L.C *et al* 1998). Electrical conductivity value of the three samples lies within the range of medium salinity zone (250-750 µs/cm) (Table-4).

Table 4: Classification of irrigation water based on WHO guide line

Zone	TDS mg/l	CONDUCTANCE, micromhos/cm
Low salinity	<200	<250
Medium salinity	200-500	250-750
High salinity	500-1500	750-2250
Very high salinity	1500-3000	2250-5000
Water Quality	TDS mg/l	CONDUCTANCE, micromhos/cm
Excellent	<200	<250
Good	200-500	250-750
Permissible	500-1500	750-2250
Unsuitable	1500-3000	2250-5000

The result of the study revealed that the mean values of total dissolved solids (TDS) were 392.3±0.04, 385.60± 0.06, and 418.67±0.23 mg/l for Sample locations AS_1, AS_2, AS_3, respectively (Table-1). Total Dissolved Solids indicates the general nature of salinity of water. Water with high TDS produces scales on cooking vessels and boilers. Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through the water (WHO, 2011). The WHO acceptable limit for potable water is 5 NTU. In the present study water turbidity values ranged from 3.5±0.14 to 4.3± 0.30 NTU(Table-1). All the samples had turbidity values within the WHO permissible value approaching to the highest permissible limit. As shown in Table-1; the alkalinity values for three water sample locations; AS_1, AS_2, AS_3 were 135.2±0.28, 140.77±0.25, 140.93± 0.81mg/l, respectively. The weathering of rocks is the potential source of alkalinity (Trivedi and Goel, 1984). The laboratory results revealed that the alkalinity values of the three sample sites exceeds the permissible limit of WHO for drinking purpose. This may be due the run off limestone containing soil in to the dam as well as weathering of rocks.

The mean values of chloride content of the samples ranges from 78.83±0.15 to 83.23 ±0.30mg/l, which is within permissible limit of WHO drinking water standard. High chloride content can cause high blood pressure in people. . The total hardness of the three sample sites, AS_1, AS_2, AS_3 were 182.8±0.20, 189.8±0.25, and 193.8±0.36 mg/l $CaCO_3$, respectively. The water containing excess hardness is not desirable for potable water (Neeraj and Patel., 2010). Khopkar (1993) classified hardness of water into 5 categories on the basis of total ion content viz. soft (0 – 40 mg/l), moderately hard (40–100 mg/l, hard (100–300 mg/l), very hard (300–500 mg/l) and extremely hard (500-1000 mg/l). Based on these classification ; the Assabol Dam water can be put in the category of hard since the total hardness value of the samples varies from 182.8±0.20 to 193.8±0.36 mg/l $CaCO_3$. These values were above WHO permissible limits for drinking purpose. The mean value of the laboratory analysis for concentration of the three sample sites (AS_1, AS_2, AS_3) of Assabol Dam water were 61±0.20, 54.10±0.16, 62.03±0.25 mg/l for Ca and 12.1±0.31, 12.4±0.10, 13.033±0.25mg/l for Mg, respectively. The sources of Ca and Mg in natural water are various types of rocks, industrial waste and sewage. There is evidence that hard water plays a role in heart diseases. Higher concentration of Mg makes the water not potable and act as laxative to human beings (Sastry and Rati., 1998). In the present study all the values were below the maximum allowable WHO level i.e. 200 and 150 mg/l for Ca and Mg, respectively. This also shows that the total discharge of calcium and Mg salts in to Assabol dam is comparatively low. The mean potassium value for the water samples (Samples AS_1, AS_2, AS_3) were 1.67±0.02, 1.83±0.04, 1.80±0.02 mg/l, respectively. All the values lie within permissible limit for drinking purpose. The mean sodium value for the water samples were 14.7±0.20, 15.8±0.20, 15.03±0.15 mg/l which also lie within the ranges of recommended permissible level of the WHO (2006) standards (1-100mg/l).

Sulphate level of Assabol dam water samples were in the range of 101.4±0.26 to 113.6±0.42 mg/l; which is also within the permissible limits of drinking water quality WHO standard (250mg/l). The nitrate level in Assabol dam water samples (AS_1, AS_2, AS_3) were 7.88±0.03, 7.61±0.29, 8.13± 0.01mg/l, respectively; which is within the WHO permissible limit (45 mg/l). According to WHO (2012), nitrate concentration above 45 mg/l, cause a disease called "Methamoglobinemia" or "blue baby" in children. The mean values of phosphate in all the water samples of Assabol Dam ranged from 1.64±0.02 to 1.76±0.20 mg/l. Phosphate has no significant adverse effect on public health. However, too much phosphate in water could lead to eutrophication.

The ammonium levels of the Assabol dam water samples(AS_1, AS_2, AS_3) were 0.31±0.02, 0.37±0.01, 0.38±0.01 mg/l $NH4^+$ respectively. Though the relative concentrations of NH_4^+ in these water samples seems very small but it is well above the WHO recommended standard of surface waters for drinking purpose (<0.2 mg/l) (WHO, 2006). This might possibly indicate the presence of anthropogenic discharges and agricultural runoff enriched in NH_4^+ input. Moreover, NH_4^+ is known to present in large concentration in decomposing organic matters and sewage discharges (CSTE, 1993). BOD concentrations obtained for the three sample sites (Sample AS_1, AS_2, AS_3) were1.85±0.04, 1.68±0.05, 1.82 0±0.01 mg/l respectively which are within the WHO permissible range.

Microbiological analysis indicated the presence of *coliforms*. All the samples were positive for *coliform* groups. The *total coliform* count of the water samples ranges from $2.06x10^5$ to 2.20×10^5 colony forming units (CFU). None of the water samples met the WHO maximum contamination level in

drinking water of zero *total coliform* per 100ml (WHO, 2006). The findings show that the Assabol Dam water is not suitable for drinking purpose without proper treatment. The sources of bacterial contamination for the Assabol Dam may be attributed to surface runoff, animal wastes, and natural soil/plant bacteria (EPA, 2002). The heavy metal contents of water and sediment samples from the Dam are presented in Table 2 and 3 above. The heavy metal concentrations in the sediment samples were higher compared to those of the water samples. This is because water sediments are metal reservoirs. Ademoroti (1996) reported that nearly all metal content in aquatic environment reside in water sediments.

3.2. Suitability of Assabol Dam Water for Irrigation Purpose

Table 5 presents physical and chemical water quality results and estimated values for irrigation. Suitability of water for irrigation purposes depended on the effect of some mineral constituents in the water on both the soil and the plant (FAO, 1985).

Table 5: Physical and chemical characteristics of Assabol Dam water for irrigation

Sample	PH	EC	TDS	Na%	Cl (meq/l)	HCO_3 (meq/l)	RSC (meq/l)	SAR
AS_1	7.8±0.10	490.2±0.30	392.3±0.04	15.3±0.02	2.19±0.23	2.6±0.01	-1.35±0.03	0.46±0.02
AS_2	8.1±0.21	482.1±0.12	385.6±0.06	17±0.02	2.20±0.15	2.95±0.04	-0.75±0.05	0.48±0.01
AS_3	7.9±0.10	523±0.29	418.8±0.23	17.3±0.15	2.34±0.30	2.93±0.02	-0.72±0.04	0.44±0.04

As shown in Table-5; the mean values of TDS values of Assabol Dam Water for the three sample location (AS_1, AS_2, AS_3) were 392.3±0.04, 385.600 ± 0.06, and 418.67±0.23 mg/l respectively. In terms of „degree of restrictions on use", the TDS values <450, 450-2000 and >2000 mg/l represent the irrigation water as „none"; „slight to moderate" and „severe", respectively (FAO 1985).

The findings from this study show that, the irrigation water of the Assabol dam, in term of TDS, is suitable for irrigation purpose. EC values also ranged from 482.10 ± 0.12 to 523.33 ± 0.29µs/cm (Table-5 and Table-1). The primary effect of high EC water on crop productivity is physiological drought. Based on the EC value (Table-4), the irrigation water of the Assabol dam can be used for irrigation purpose with moderate leaching as it falls under medium salinity. As shown in Table-5, the values of SAR of the collected water samples range from 0.44±0.04 at AS_3 to 0.48±0.01 meq/l at sampling site AS_2. Water with SAR ranging from 0 to 3 is considered good and with greater than 9 is considered unsuitable for irrigation purpose as it affects soil structure (FAO, 1985). The present result of SAR for water samples (AS_1, AS_2, AS_3) of Assabol Dam are less than 9 indicating excellent quality for irrigation. The water with high RSC has high pH and land irrigated with such water becomes infertile owing to deposition of sodium carbonate. In the present study the estimated RSC. values for water samples (AS_1, AS_2, AS_3) were -1.35±0.03, -0.75±0.05, -0.72±0.04 meq/l respectively (Table-5) and at all sampling stations the RSC value were below1.25 meq/l (Table-6). It can then be concluded that water of Assabol Dam can be considered safe for irrigation purpose in terms of its RSC value. The usual toxic ions in irrigation water are chloride, sodium and boron. Each can cause damage, individually or in combination. As shown in Table-5; the Chloride (Cl^-) content of the irrigation water samples of the study area varied considerably ranging from 2.19 ±0.23 at AS_1 to 2.34±0.3 meq/l at AS_3 and this might be due to settlement and anthropogenic effect and municipal waste flowing from the watersheds to Assabol flood water harvesting dam

Table 6: Water quality classes for agricultural irrigation (FAO 1985)

Specific ion toxicity							
	Degree of restriction on use				Degree of restriction on use		
	low	Medium	High	Very high	None	Slight to moderate	Sever
Na^+(SAR)	<10	10-18	18-26	>26	<3	3-9	>9

Irrigation water classification Irrigation water classification							
	Safe	Sensitive plants	Moderately to tolerant plants	Unsuitable for tolerant plants	No poblem	Increasing problem	Sever problem
Cl^-(meq/l)	<2	2-4	4-10	>10	<4	4-10	>10

Miscellaneous Effects						
	Irrigation water classification			Irrigation water classification		
	Safe	Permissible	Unsuitable	None	Slight to moderate	Sever
HCO_3 (meq/l	-	-	-	<1.5	1.5-8.5	>8.5
NO_3-N(mg/l)	-	-	-	<5	5-30	>30
PH	-	-	-	Normal range : 6.5-8.4		

As shown from Table-6; it is evident that the mean values of Cl of the study area were found in the class of no problem and having certain problem on Cl sensitive plants or crops (FAO, 1985). The results in Table-5 also indicates that the mean value of bicarbonate (HCO_3^-) of irrigation water samples (AS_1, AS_2, AS_3) of the study area was between 2.6±0.01, 2.82±0.04, 2.95±0.02 meq /l respectively and the water samples of the study area fell into „slight to moderate" degree of restrictions on use. The results from the three samples (AS_1, AS_2, AS_3) for nitrate were 7.88±0.03, 7.61±0.29 and 8.13±0.01 mg/l. These values lie within the class from „Slight to moderate „showing that the water is suitable for irrigation use in terms of its nitrate

concentration. As shown in Table 5 the concentration of the selected heavy metals in Assabol Dam water were below the maximum permissible limit except for cadmium which is below the detection limit and copper in which its concentration is above maximum permissible limit of FAO 1985.

3.3. Suitability of Assabol Dam Water for Fish Culture

Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983). The acceptable level of the temperature for fish culture is from 15-35^{0}C and the temperature values of Assabol Dam water samples; (19-20C^0) lie within acceptable range. Therefore the water is suitable for fish culture in terms temperature. As shown from Table-1; the PH values of the three samples (AS_1, AS_2, AS_3) of the dam water were 7.8±0.10 and 8.10± 0.21, 7.9±0.10 respectively. At low pH, metals toxic to fish and shellfish can be leached out of the soil and at high pH, the toxic form of ammonia becomes more prevalent (Boyd, 1990). According to Lawson (1995), all water samples of the dam lie within recommended or acceptable level for fish culture. As the result water is suitable for fish farming regarding the adverse effect PH. According to Bhatnagar and Singh (2010) and Bhatnagar *et al*. (2004) DO level >5ppm is essential to support good fish production. The findings from this study showed that DO levels of the samples were 7.19, 7.29, and 7.20 ppm in which all the values were in permissible limit. BOD concentrations of the three sample sites(AS_1, AS_2, AS_3) were 1.85±0.04, 1.68±0.05, 1.82±0.01 mg/l respectively(Table-1). Bhatnagar and Singh (2010) suggested the BOD <1.6mg/l level is suitable for pond fish culture and 1-2mg/l is the desired level of BOD. From this, it can be conclude that the BOD concentration for all sample sites were in desired level for suitability of the dam water for aquaculture.

The alkalinity of the water samples (AS_1, AS_2, AS_3) were 135.2±0.28, 140.77±0.25, 140.93± 0.81mg/l respectively(Table-1). Bhatnagar *et al* (2004) suggested that alkalinity <20ppm indicates poor status of water body, 20-50 ppm shows low to medium, 80-200 ppm is desirable for fish and >300 ppm is undesirable. Our result showed that alkalinity values of the water samples lie within recommended range by Bhatnagar *et al* (2004). Hardness values of the three samples (AS_1, AS_2, AS_3) of Assabol Dam water were 182.8±0.20 to 189.8±0.25, 193.8±0.36 mg/l $CaCO_3$ respectively(Table-1). According to Bhatnagar *et al* (2004) hardness values less than 20 ppm causes stress, 75-150 ppm is optimum for fish culture and >300 ppm is lethal to fish life as it increases pH, resulting in non-availability of nutrients.

Santhosh and Singh (2007) recommended nitrite concentration in water should not exceed 0.5 mg/l. The result of the present study indicated that NO_2^- concentration of water samples (AS_1, AS_2, AS_3) were 0.023±0.01, 0.015±0.01, 0.01667±0.02 mg/l respectively were in recommended desired level for fish. Concentration of nitrate in the water samples (AS_1, AS_2, AS_3) were 7.88±0.030, 7.61±0.29, 8.13± 0.01mg/l respectively were within acceptable range i.e <100mg/l (Santhosh and Singh , 2007). The agricultural practices at catchment area and the municipal waste flow by the flood from upstream of the watersheds might be the cause for reported nitrate concentration in Assabol flood water harvesting Dam.

4. Conclusion

The findings from this study showed that though the quality of the dam water for most of the physical-chemical water quality parameters were within the range of permissible limit; some of the physical and chemical characteristics of the Dam water (Total hardness, ammonium, Alkalinity) as well as bacteriological quality parameters (*total coliform*) and heavy metals (Lead (Pb) concentration) exceeded the maximum permissible limit of WHO standard for drinking water.

Similarly, the suitability of Assabol Dam water for irrigation purpose ; irrigation parameters such as SAR, RSC , EC, and specific ion toxicity (Na%, Cl^-) and as well as pH , HCO_3-, and NO_3^-were found to be within maximum permissible limit of FAO 1985 except the Cl^- concentration that might be toxic to Cl^- sensitive crops. The findings also indicated that the water is safe for fish purpose.

The study also revealed that there is a need for proper watershed management and water quality monitoring of Dam water for safe and sustainable use of the water by communities.

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