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Water Quality Assesment of Chole Stream Using Some Physico-Chemical Parameters and Water Quality Index

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Abstract

This study aimed to assess the quality of Chole River water in Toke kutaye district based on some physicochemical properties and Water quality index. Chole River crosses the town and expected to be polluted by different pollutants. To take the sample for the analysis of the physico chemical properties of water, the river divided in to four stations along the stream, with one-kilometer interval apart from the upper to lower. Water sample were collected using a 500 ml plastic bottle. For each station, some of physic-chemical parameter such as PH, Temperature, Electrical conductivity, Total Dissolved oxygen, and total hardness were observed. Laboratory results using different chemicals were used to analyze the data collected from the sample. The individual parametric result from the laboratory showed that all values of the parameter observed were less than permissible standard of drinking water given by WHO. Some of them were PH (7.9), DO (103.2 mg/l), TDS (103.5 mg/l), EC (157.22 mg/l) and hardness (36.5 mg/le). This implies as chole water suitable for drinking water. However, the best indicator of quality of drinking water, which is WQI, indicates, as the stream was not suitable for drinking water. WQI were varying from station to station. The highest numbers of WQI exhibited was on site three (487.52). This indicates that the stream needs more protection in order to make it suitable it for drinking water. Thus, it is possible to recommend that the people near to the water should have to aware about the problem of the stream and refrain them themselves from drinking it.

Keywords: Cholie; Water quality; Physico chemical; Index; Station

Introduction

Water quality is a critical factor affecting human health and welfare. Studies showed that approximately 3.1% of deaths (1.7 million) and 3.7% of disability-adjusted-life-years (54.2 million) worldwide are attributable to unsafe water, poor sanitation and hygiene [1]. The problem is the backward socio-economic development resulting in one of the lowest standard of living, poor environmental conditions and low level of social services [1,2].

The functioning of an aquatic ecosystem and its stability to support life forms depend a great extent, on the physicochemical characteristics of its water. Physico-chemical parameters are highly important with respect to the occurrence and abundance of species. Ground water is by far more abundant than surface water and its quality is as important quantity. Water meant for drinking must therefore meet quality standards. Water quality is, essentially determined by its physical and chemical characteristics [1].

Naturally, ground water contains mineral ions. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and aquifer. Good quality of water resources depends on a large number of physio-chemical parameters and biological characteristics. For monitoring and evaluation of the water quality frequent sampling and analysis is mandatory [3]. Thus, the general objective of this study is evaluating the quality of the stream water weather it is as per the standard for the current use or not with its weighted parameter values and generating the base line data for this stream as it is a pioneer investigation for the streams.

Materials and Methods

Description of the study area

Guder town is located in Oromia Zone approximately 11 km west of Ambo and 137 km from Addis Ababa. The study area has Temperature ranges 16°C to 21°C and rain fall measured between 800 mm to 1100 mm with an elevation of 1800 to 2300 meters above sea level. It has an estimated total population of 19525, Male 9727 and Female 9798 (Woreda Office, 2017). Since Chole River flows through the town and used for different purpose it has ecologically and economically important for the town and the surrounding population. In the upper watershed, the stream used as a source of irrigation water with a number of canal diversion to small-scale irrigation sites. The stream banks are using as waste damping sites, and as an agent for transporting the damping waste during the time when the rive will have maximum flow

Sampling stations

Four stations selected along the river length of about 4 km, and each sampling station has been 3-point stretch across the stream and the station taken one kilometer apart. The water depth identified at a minimum of 50 cm that capable to immerse plastic and taking sample. Station one (S1) is located upstream and at upper side of Guder town. It has relatively high flow, and a sandy and rocky floor. Around the river banks different exercises are undergoing among these small-scale irrigation and different farming activity are undergoing. In addition, human activities include, fetching, washing cloth and bathing are exercising. The second, station two (S3) is located at side of Guder campus and susceptible to solid waste disposed from the campus and other sides (oboist sides) of the river different agricultural activities are undergoing. Station three (S3) is located at the back of the market area and It is

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characterized by moderate flow rates, which sediments coming on the upper region is deposited and surrounded by settlements. Therefore, these settlors were using the stream for their livelihoods including the domestic uses. The fourth one, station four (S4) is located at the end of the town and its stream cross the main road which expected to have more source of pollution because peoples are damping the waste to the bank of the stream around the roads.

Sampling and preservation

The plastic bottles were use as instrument for collecting samples from four sites along the Chole stream. All of the collected the samples were yellowish and odorless. Composite sampling with the aid of plastic drawer drew samples into three same types of polyethylene bottles i.e.500 ml for physic chemical parameters in the four sites. The plastics bottles were previous washed with the distilled water to avoid any kind of contamination during sampling extra care has taken and the bottles are rinsed several times with the distilled water before it has been filled. On-site measurement were done for Temperature and PH, since they are unstable by their nature, while the other parameter were transported to chemistry laboratory of Ambo university for analysis by keeping them at 4°C using ice box.

Data collection method

The stream has been segregated in two three parts; based on the suspected source of pollution. Sampling point one (S1) was situated on the upstream parts where the stream was only surrounded by only agricultural activities and there is no influence of the town. S2 and S3 are the sampling points where in the town which were a point to see the source of pollution in the domestic or municipals. The last sampling point S4 was at the down streams, which is located below the town, and the downstream farmers were using it for different purposes including for drinking purpose. Except temperature all the sample have moved to the laboratory to with its standard transportation mechanism.

Data analysis procedures

Physiochemical parameters of the sample analyzed in the laboratory except temperature and PH, which have measured on the site since they are volatile. The samples kept in refrigerator to preserve the quality of the samples until it goes to the laboratory processes. Standard method of analysis employed in different physiochemical parameters determined. The temperature of each sample measured and recorded using calibrated thermometer, in degree Celsius (°C) units. PH had measured and recorded by using PH meter. The alkalinity of each water sample have analyzed by using phenolphthalein indicator and methyl orange and indicator. Total dissolved solid measured by Gravimetric, Dissolved Oxygen measured by Probe method and Total hardness of water estimated by complex metric titration with EDTA.

$$\text{Total Alkalinity (TA)} = (OH^-)+(HCO_3)+(CO_3^{-2})-(H^-) \quad \text{---------- (1)}$$

$$\text{The concentration of } OH^- = \frac{\text{Concentration of H2S04 x volume of H2So4}}{volume\ of\ samples} \quad \text{---------- (2)}$$

$$\text{The concentration of } C0_{3=2} = \frac{(volume\ of\ H2S04)x\ concentratioon\ of\ H2So4}{volume\ of\ samples} \quad \text{---------- (3)}$$

$$\text{Concentration of } HCO_3 = TA - OH - CO_3 + H \quad \text{---------- (4)}$$

$$\text{Total harnesses of sample} = \frac{V.EDTAx\ concentration\ of\ EDTA}{Volume\ of\ sample} \quad \text{---------- (5)}$$

Method used to determine water quality index

Weighed arithmetic water quality index method classified the water quality based on the degree of purity by using the most commonly measured water quality variables. The method has been widely used by various scientists [4] and the calculation of WQI was made by using the equation: WQI=ΣQiWi/ΣWi and classification of water quality based on weighted arithmetic WQI Method (Table 1), as adopted from (Chatterji, Raziuddin, et al.). The quality rating scale (Qi) for each parameter was calculated by using the expression:

Qi=100[(Vo-Vi/Sn-Vi)] ---------- (6)

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

Table 1: Classification of water quality based on weighted arithmetic WQI method

Where, Vo is estimated concentration of ith parameter in the analyzed water, Vi is the ideal value of this parameter in pure water VI=0, except parameters pH and DO (7.0 and 14.6 mg/l respectively). Sn is the recommended standard value of nth parameter. The unit weight (Wn) of each parameter obtained from ICMR/BIS (Table 1).

Materials and chemicals

Apparatus and instruments: Polyethylene bottle, pH meter, oven, balance, glass bottles, Thermometer, desiccators, Conductivity Meter, Measuring Cylinder, Filter paper, Conical flask, Burette, Pipette, Beaker, Measuring flask. Reagents and Chemicals: 0.1 MEDTA solution, EBT indicator, Basic buffer solution (NH4OH and NH4Cl), Standard hard water, given water sample.

Determination of the parameters used for the study

Almost all the parameters used for this study have done in the chemistry laboratory of Ambo University except PH and Temperature. PH and Temperature were measured by using PH meter and thermometer respectively. Finally, the observed results were analyzed along internationally accepted standards of that parameter permissible in drinking water, which indicated under (Table 2).

S n.	Parameters	Standards	recommending agency	unit weights
1	PH	6.5-8.5	ICMR/BIS	0.219
2	DO	5	ICMR/BIS	0.3723
3	TDS	500	ICMR/BIS	0.0037
4	EC (µS/cm)	300	ICMR	0.371
5	Total hardiness	300	ICMR/BIS	0.0062
6	Salinity (ppt)			
7	Alkalinity (ppm)	120	ICMR	0.0155
8	free carbon dioxide (ppm)			
9	Water temperature(°C)		WHO	15

Table 2: Drinking water standard recommending agency and unit weights.(all value except PH , salinity and EC are in mg/l).

Results

The 12 samples taken from the stream have analyzed with three replication and the average values of the replica has presented for each parameters. The parameters such as Water temperature, DO, PH, TDS, EC, Total hardiness, salinity, alkalinity and free carbon dioxide have used as an indicator of the waters quality of the streams since the source of the pollution is expected, as it would be the municipals based on the preliminary surveys.

The parameters were taken from four different stations. Statio 1 of the upper part of the stream; station 2, at the intermediate between the middle and upper stream, station 3 , is at the mid part of the town and station 4 at the lowest part of the stream in order to see the spatial distribution of the wastes and it's source. All the analytical procedures used in the physicochemical analysis of the water samples were executed according to standard method of water and waste water analysis [5]. As indicates in Table 3, the result presented the spatial stratification of the physico-chemical parameters from S1 to S4. For grading the water quality there should be a single values speaking about the different water quality parameters in Table 4, had been used for presenting the water quality index. The Water Quality Index is used to aggregate diverse parameters and their dimensions into a single score, displaying a picture of the water quality of source water body of the analytical methods for each parameter are listed below;

Parameters	S1	S2	S3	S4	Average	WHO limits
Water temperature(°C)	25	24	26	26	25.25	15
PH (PH unit)	8	7.7	7.9	8	7.9	6.5-8.5
DO (mg/l)	108.8	86.4	130.2	86.4	103.2	200
TDS (mg/l)	100	105	104	105	103.5	1000
EC (µS/cm)	153.3	157.2	160.6	157.8	157.225	1500
Total hardiness (mg/l)	44	42	38	22	36.5	500
Salinity (ppm)	0.07	0.07	0.07	0.08	0.0725	600
Alkalinity (mg/l)	6	10	5	14	8.75	200
Free carbon dioxide (ppm)	15.0018	10.0012	26.00312	9.00108	15.0018	

Table 3: Site variation of the physic-chemical parameters of chole stream water

Parameters	Observed value	Standard value(sn)	unit Weight (Wn)	Quality Rating (qn)	Wn qn
Water temperature(°C)	25				
PH (PHunit)	8	8.5	0.219	66.67	14.6007
DO (mg/l)	108.8	5	0.3723	981.25	365.3193
TDS (mg/l)	100	500	0.0037	20	0.074
EC(µS/cm)	153.3	300	0.371	51.1	18.958
Total hardiness (mg/l)	44	300	0.0062	14.67	0.09095
Salinity (ppm)	0.07				
Alkalinity (mg/l)	6	120	0.0155	5	0.0775
free carbon dioxide (ppm)	15.0018		-		
			∑Wn=0.9877	∑qn=1138.69	∑Wnqn=399.120
Note: Water quality index=∑ Wn qn/∑Wn=399.120/0.9877=404.09					

Table 4: Calculation of Water quality index for station one

Discussion

Temperature

Temperature is one of the most important factors in the aquatic environment, which affects the physical and chemical properties of water and affects the aquatic vegetation, organisms and their biological activities (BK Dwivedi, GC Pandey, et al.). The quality standard for effluents discharge published by the Ethiopian ministry of water (MOWR)

and the basic environmental water quality standards for a small river in Flanders (Belgium) showed the temperature ranges from 15.5-26.4. The result obtained from water samples s1, s2, and s3 and s4 were, 25, 24, 26 and 26 respectively. Thus, the study stream water has a temperature above recommended standards limit of WHO (15°C). A temperature of station three and four has the same and relatively higher value. These stations found in the middle part of the streams and at the end of the town. Thus, the increment of temperature in these stations is resulted from the pollutions released from the municipalities. This increment trend of temperature of the stream leads the water will going out from the desired standards of water quality for drinking purpose based on this single parameters of temperature (Figure 1).

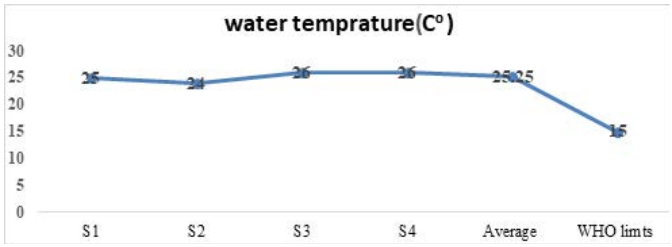

Figure 1: Spatial Variation of Observed Temperature

Potential Hydrogen (PH)

The pH (Potential Hydrogen) of a solution refers to its hydrogen ion activity and expressed as the logarithm of the reciprocal of the hydrogen ion activity at a given temperature. The permissible limit of PH in drinking water is within 6.5 – 8.5 (Sajitha V, Smitha Asok Vijayamma, et al.). The PH value obtained from the samples at s1, s2, s3, and s4 are, 8, 7.7, 7.9 and 8 respectively and the average value of this PH is 7.9. So, it found within the permissible limit of WHO. Based on the Guideline the parameter analyzed by PH meter immediately on field indicates the stream water is still at optimal levels of acidity for the desired use.

Total dissolved solids

Total dissolved solids (TDS) denote mainly the various kinds of minerals present in water. Water with high TDS value indicates that water is highly mineralized (Meride, Ayenew, et al.). Desirable limit for TDS is 500 mg/l and maximum limit is 1000 mg/l that prescribed for drinking purpose prescribed by IS 10500 and BIS. The concentration of TDS of the present study at s1, s2, s3 and s4 were 100 mg/L, 105 mg/L, 104 and 105 mg/L respectively. The average, which obtained from those points, was 103.5 mg/which is below standard of [1]. The maximum permissible limit of TDS for drinking water is 1000 mg/L. With respect to the spatial dimensions different numerical values have been recorded the grater values and below S2. This is because of the expected source of pollution from the municipalities and which shows similar trends with the study by (Wiberg, et al.).

Dissolved Oxygen (DO)

Dissolved oxygen (DO) needed for aquatic life or other stream organisms. In unaltered streams, dissolved oxygen levels usually determine the ability for the stream to support aquatic oxygen-dependent life. It depends on volume, flow and temperature of water, Turbulence, interaction with the air, and photosynthesis replenish oxygen in the water. Cold water can hold more dissolved oxygen than warmer water. Dissolved oxygen expressed as, a concentration, milligrams per liter (mg/L), or as percent saturation, (the amount of oxygen the water holds compared to what it could absorb at that temperature). The samples taken from four sampling sites of stream and analyzed in the lab indicated i.e. taken from s1, s2, S3, s4 and the results obtained from these station were indicated 108.8, 86.4, 131.2, and 86.4 mg/L respectively. The spatial distribution of the dissolved oxygen implied that high at station one and in the rest three stations there were less decomposed organic matter, more Turbulence due to slope of land and in addition station is a point where the river channel is covered relatively with dens grass and vegetation than the other. Whereas the result in this study showed that there is relatively decrement of the dissolved oxygen concentration by which this is an indirect implication of there were more concentrated organic matter, and there is a process of organic matter decomposition, less turbulence of water (Figure 2).

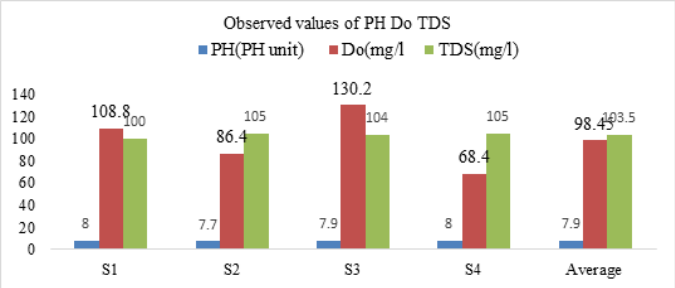

Figure 2: Spatial distribution of PH, Dissolved oxygen and total dissolved solid

Electrical conductivity

Pure water is not a good conductor of electric current rather it is a good insulator. Increase in ions concentration enhances the electrical conductivity of water. In fact, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceeded 400 µS/cm. The current investigation indicated that, EC value from S1, s2, s3 and s4 ranges were 153.3, 157.2, 160.6, and 157.8(µS/cm) respectively. The result were varies from station to station which shows an increasing trend from station one to station three. This indicates that, addition of wastes contains an ion, which increases EC. Nevertheless, unexpectedly it decreases as our points far away from which more concentration enter into stream. When the analyzed values compared to WHO, it was below permissible limit standard and no problem to use it. Similar value reported by (Alemu et al.) physico-chemical parameters of drinking water of turkey. Therefore, this result clearly indicates that water in the study area was not considerably ionized and has the lower level of ionic concentration activity.

Salinity

Water is universal solvent because of ability to dissolve other compounds; salts come from organic materials such as, leaves, silt, plankton and sewage or inorganic materials such as rock and rain. Salinity is the mass of the dissolved salts substance in samples of water and used to measure the amount of salts in the water. Salt affects the quality of water used for irrigation or drinking and have a critical influences on aquatic biota [6]. The water sample taken from four stations and analyzed in laboratory and obtained result from s1, s2, s3 and s4 were 0.07, 0.07, 0.07 and 0.08 mg/L respectively. In addition, the average value of the result is 0.0725 mg/L, which is under the permissible limits of the drinking water.

Hardness

The value of hardness evaluated in laboratory analyses from four sta-

tions of sampled water s1, s2, s3, and s4 and the result obtained were 44, 42, 38, and 22 respectively. The average value of total hardiness was 36.5. The result obtained from these data indicates that it were decreased gradually from station one to station four and these implies hardiness capacities of water is dropped as pollution concentration increased down ward the stream [7,8]. The result was below the limited standard measurement, but deceasing along the stream. This is because of, the hardness is expected from the minerals and rocks which the bed of the stream channel will have direct contact with the water; however in this study the stream bed is covered with source of pollution coming from the municipalities so as the water might not have direct contact to the bed of the streams [9,10]. The recommended upper level for drinking water is 50 mg/L, in order to not to being the health risks of the human being while the streams was directly used for drinking purpose (Figure 3).

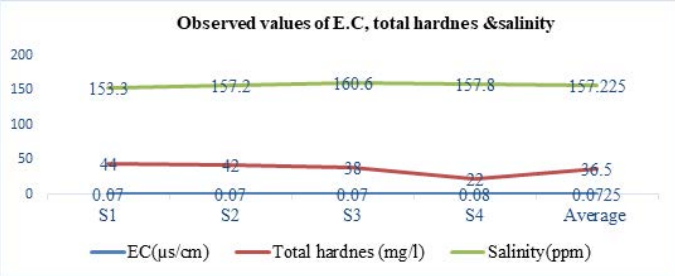

Figure 3: Indicate Electrical conductivity, Total hardiness and salinity

Alkalinity

The total alkalinity of analyzed samples of water taken from all stations was ranged 6, 10, 5, 14, respectively from station 1 to 4. The minimum value recorded at station three was 5 mg/l and maximum value was at station four, which was 14 mg/l. The recorded value from all the sampling station is below the permissible limits of the recommended standards even though there was some spatial variation along the stream channels [11-14].

Free CO_2

The values of free carbon dioxide indicated a maximum values at station three (S3). This is the station where the major source of municipal waste is joining the streams that the decomposition process is expected [15]. The decomposition processes are again could be source of carbon dioxide (Figure 4).

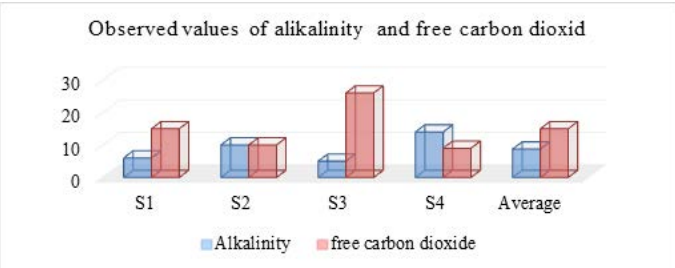

Figure 4: Shows Estimated Values of Alkalinity and Free Carbon dioxide

Determination of water quality index

The result obtained from the calculation of weighted arithmetic means of water quality index methods vary from station to station. As indicated on the above Tables 4-7, the result was 404.09, 312.28, 487 and 316.810 for station one, two, three and four respectively [16-20]. All of the result were above (>100) a maximum value of the classification of WQI based on weighted arithmetic WQI method. From the result, it clearly understood that the stream is overabundance pollution based on the index, the decomposition of which kills animal life by depriving it of oxygen [21,22]. Moreover, it is also observed that the extent of pollution from station to station relatively vary which was higher on site one and three. The highest value of WQI on site one might be caused by fertilizer drained from nearby farm land and concentration animal feeding near to the streams, while the one on site three may be caused by much of organic wastes damped on the river bank from the center of the town [23-25].

Conclusion

In any creature, clean and fresh water is mandatory for the life to be continuing. The functioning of an aquatic ecosystem and its stability to support life forms depend largely, on the physicochemical characteristics of its water. Physico-chemical parameters are highly important with respect to the occurrence and abundance of species. For having such forms of ecosystem and accessing fresh water continues monitoring, and evaluation of the natural stream is mandatory. The current study conducted was aimed at evaluation of the current status of the stream water quality for the intended use and creating bench mark data base for the coming monitoring and evaluation works performing by the concerning bodies. The study was evaluated the streams water quality based on the physico-chemical parameters which they have been taking at four station 4 kms apart each other except temperature and PH of volatile parameters measured on the site immediately the samples have been taken to the laboratory and passed through the standard laboratory processes. The result obtained from the laboratory analysis at each satiation presented independently to see the spatial variation of the pollution. Almost all the results implied that, the stream water had relatively polluted at station three (S3) where it is a sampling point at the middle of the urban and most of the municipal waste have been damping near on the riverbanks. The individual parametric values showed that the water is still in good condition. However, for any water source to speak whether is good or not for the intended use, there should be there should be a weighted values, which is a water quality index. The water quality index for the stream indicates that, 404.09, 312.28, 487 and 316.810 for station one, two, three and four respectively and all the values were above the recommended water quality index values. Therefore, as the water quality index obtained from analyzed sample shows that, chole stream water is more polluted and not suitable for domestic purposes such as drinking, washing, cooking and bathing.

In general, the stream water still needs further investigation with respect to different time and additional parameters like biological indicators to understand the general ecosystem characters. In addition, to use for the intended uses, the stream bank should be free of waste damping and there should be buffer zone free of settlement.

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