Journal of Natural and Allied Sciences
Vol. II No.1, pp. 10-15, December 2018

Water Quality Assessment of Agno River Tributaries in Eastern Pangasinan for Irrigation Purposes

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Abstract *– This study was conducted to assess Agno River tributaries for irrigation purposes. Water discharge, coordinates and water samples for laboratory test, were gathered simultaneously. Results and findings revealed that water quality indicators and the water discharge at the study sites are all safe to use for irrigation. The pH of the water samples tested is within the normal range from 6.0 to 9.0. Amounts of sodium are within the optimum range of 0-50 ppm. Detected amounts of sulfate are too low to exceed the optimum amount of 400 ppm. Chloride contents of the water samples were below the normal range of 350 ppm. Boron contents are below the normal range of 0.75 mg/l. It was then observed that there was dumping of garbage along the banks of Agno River which may cause water quality deterioration in the future. It is recommended that the Clean Water Act and Solid Waste Management must be strictly implemented along the river. Water quality analysis in Agno River and proper monitoring is necessary to determine the changes or any detrimental ills that may affect the irrigation water and to develop solutions for water resource problems that may affect plant growth.*

Keywords *– Irrigation, Water Discharge, Water Quality, Water Resources*

INTRODUCTION

Irrigation is the key input in crop production. Full benefit of crop production technologies such as high yielding varieties, fertilizer use, multiple cropping, crop culture and plant protection measures can be derived only when an adequate supply of water is assured and good quality irrigation water is essential to maintain the soil-crop productivity at a high level. On the other hand, optimum benefit from irrigation is obtained only when other crop production inputs are provided and technologies applied [1].

Rivers are the source of water for most irrigation systems, the amount of discharge and elevation of water surface are pertinent to predict the amount of water available.

Agno River is a river in the province of Pangasinan which is 206 km long. Roughly 2 million people live in the Agno River Valley and comprise one of Philippines' larger population clusters. The government established Agno River irrigation system to provide irrigation water to some 60 to 100 sq. km. of rice lands in Pangasinan. [2].

The Agno River basin is plagued with issues of water quality, water quantity and water space brought about by competing demands for water [3]. Issues include pollution of rivers – solid and liquid wastes and no river monitoring undertaken in most rivers.

The changes in quantity and quality of soil and water as a result of irrigation and the ensuring effects on natural and social conditions at the tail-end and downstream of the irrigation scheme are the environmental impacts of irrigation [4]. The size of a waterway and its flow rate affect its water quality. This is one reason for measuring flow - to work out the load of contaminants and sediment the waterway is carrying. The discharge can have a significant effect on water quality. It is important that it is recorded at the time of sampling and, if possible, during the previous few days. It is particularly valuable to know if flows are at low, moderate or high level and if the level is rising or falling [5].

One of the simplest ways of measuring velocity and discharge in a stream is by float method. The best object float is just beneath the surface to avoid wind effects. By measuring the time the float takes to travel downstream over a known distance, to obtain an estimate of the surface velocity. Repeating the float measurement over the same stretch of stream but at various distances from shore will give a rough estimate of the average surface velocity [6].

Water quality monitoring can be used for many purposes: To identify whether waters are meeting designated uses and to identify specific pollutants and sources of pollution. Water quality monitoring helps link sources of pollution to a stream quality problem because it identifies specific problem pollutants. Since certain activities tend to generate certain pollutants a tentative link might be made that would warrant further investigation or monitoring [7].

On a study at Mamba River, it was monitored for 12 months and has an average increase of pH of 2 units, meaning, the water is safe for aquatic organisms. Chloride level has an average value of 0.07 mg/L during the rainy season and decrease by 0.06 mg/L during cool dry season. The presence of chloride in a very small amount was also detected at Mamba River. This is good because high chlorine content can cause poisoning of aquatic organisms [8].

Santa Cruz River was assessed based on the biological, bacteriological and physicochemical parameters collected during May and November sampling. Chloride value ranged from 11 to 37 mg/L in May and 7 to 15 mg/L in November. All values are below the criterion for Class C waters. The pH value of water samples collected in May range from 5.8 to 7.4. Out of the15 stations, 12 stations passed the DENR criterion set for pH value while 3 stations obtained a pH value of 5.8 (Station 9) and pH of 6.4 (Stns. 8 and 13), which are below the criterion set for Class C waters [9].

Based on physico-chemical, microbiological and biological assessments of the Sapang Baho River, it generally signifies that there is input of organic pollution both from domestic solid and liquid wastes. Solid wastes (garbage) were very visible in all the stations. Parameters like pH, total dissolved solids, nitrates, chloride and heavy metals (Cadmiun and Lead) were within the allowable limits based on Class C Water Quality Criteria. Other parameters could not be assessed due to lack of allowable limits based on DAO 34 [10].

On the Revised Water Usage and Classification/Water Quality Criteria that irrigation water (Class D), the pH ranges 6.0 – 9.0, Boron content should not exceed 0.75 mg/l (0.75 ppm) and chloride of 350 ppm [11]. Irrigation water must have sodium content desired range of 0-50 ppm and sulfate content not exceeding 400 ppm according to [12].

OBJECTIVES OF THE STUDY

This study was conducted to assess the water quality of Agno River tributaries for irrigation purposes in Eastern Pangasinan. Specifically, this study aims to: (1) identify and locate the tributaries and irrigation lateral canal along the Agno River as the sites of the study; (2) identify the problems based on the analysis of data gathered and propose possible approaches to mitigate problems related to water quality of the Agno River.

MATERIALS AND METHODS

The following materials were used during the conduct of the study: (a) Global Positioning System (GPS) device; (b) Stop watch; (c) Plastic bottles; (d) Floating device (Orange); (e) Meter stick; (f) Tabulation sheet; (g) Measuring tape; (h) Pen/Pencil/Marker.

The Agno River system from ARIS Weir, San Manuel, Pangasinan (station 39+557) to Carmen Bridge, Rosales, Pangasinan (station 01+345) was considered as the study site.

A brief procedural description of the study was presented in a flow chart as shown in Figure 1.

Location of study sites were identified through Google Earth Pro. Water samples for laboratory test, water discharge and coordinates were gathered simultaneously.

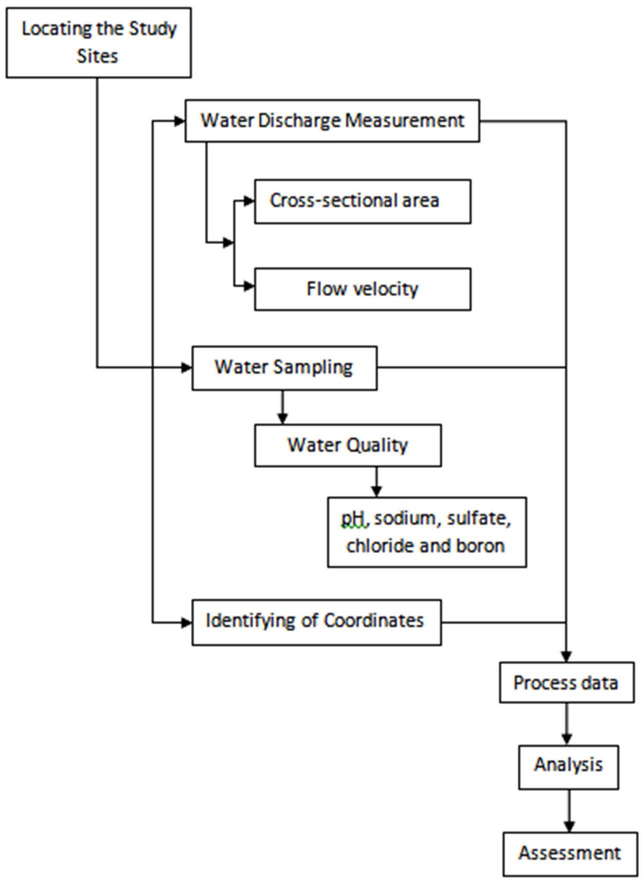

Fig. 1. Procedural Flow Chart

Water Quality

Water samples were taken from the designated study site. One hundred cubic centimeter of water was collected at an average depth at the tail end of the tributary. The collected samples were transferred to 1-liter plastic container. The container was tightly covered. The gathered water samples were put into a cooler to preserve the trace elements and sent to the Bureau of Soil and Water Management Center for the Laboratory test. Water quality indicators determined were pH, Sodium content, Boron content, Chloride and Sulfates.

Water Discharge

Measurements of water discharge were done using the float method. Water discharge was computed using the formula:

$$Q = AVC$$

where, Q = flow rate, volume per unit time;
A= cross-sectional area of flow;
V = mean velocity;
C = correction factor (0.8 for rocky-bottom streams or 0.9 for muddy/sandy-bottom streams).

To find the cross-sectional area of the stream, width and depth were measured across at a cross section where it is safe to wade. To determine the average cross-sectional area, ten depths were measured. Total width was divided by 11 for the regular interval of ten depths. A meter stick was used to measure the depth.

Average cross-sectional area was computed using the equation:

$$A = (d_1 + d_2 + d_3 + d_4 + d_5 + d_6 + d_7 + d_8 + d_9 + d_{10})(w_i)$$

where, A = average cross-sectional area
d_n = measured depth
w_i = width interval

To find the velocity of the water, a 10-meter length of the stream was marked off. A section that was relatively straight and free of vegetation or obstacles was chosen. A person was positioned at each end of the section. Float was placed on the surface near the middle of the stream at least two-feet before the starting point. When the float was at the starting point, the timer was begun using a stopwatch. The timer was stopped when the float reached the marked endpoint. Orange is used as a float because it has the right buoyancy and is quite visible [6]. The procedure was repeated three times in each designated points.

Mean flow velocity of the stream was computed using the equation:

$$V = \frac{\left(\frac{10}{t_1} + \frac{10}{t_2} + \frac{10}{t_3}\right)}{3}$$

Where, V = mean velocity
t = time traveled to reach the designated points by the float

Data Mapping

Coordinates of the study sites were determined using a GPS device with a reference to a set of axes. The gathered data was plotted using Google Earth Pro.

Method of Data Analysis

The analyses of data were done using descriptive statistics

RESULTS AND DISCUSSION

There are nine study sites identified in the Agno River from station 39+557 to station 01+345 as shown in Table 1 (upstream to downstream). These are the nine tributaries located at Brgy. San Rafael of San Nicolas, Brgy. Barangobong and two stations in Brgy. Legaspi of Tayug, Brgy. Cabalitian of Asingan, Brgy. San Vicente and Brgy. Callitang of Sta. Maria and Brgy. Carmay and Brgy. Tomana of Rosales, Pangasinan

Table 1. Coordinates of the five study sites.

Study Site	Latitute	Longitude
San Rafael	16˚3'27.33"N	120˚43'44.89"E
Legaspi 1	16˚2'55.69"N	120˚43'36.10"E
Legaspi 2	16˚2'41.67"N	120˚43'34.50"E
Barangobong	16˚0'21.33"N	120˚42'53.77"E
San Vicente	15˚59'45.19"N	120˚42'29.70"E
Cabalitian	15° 58.734′ N	120° 38.947′ E
Callitang	15° 57.196′ N	120° 39.528′ E
Carmay	15° 54.515′ N	120° 37.339′ E
Tomana	15° 53.786′ N	120° 36.946′ E

Water Discharge

The water discharge is shown in Table 2 including its velocity and cross-sectional area. From the nine tributaries, the study site on Brgy. Cabalitian, Asingan has the highest water discharge of 4.523 m^3/sec while on Brgy. Callitang has the least with 0.057 m^3/sec. All of the water discharges on the nine tributaries has no adverse effect on the quality of the water for irrigation purposes.

Table 2. Velocity, Cross-sectional Area and Water Discharge of the study sites

Study Site	Cross-Sectional Area (A)	Velocity (V)	Discharge (Q)
San Rafael	3.22	1.04	2.68
Legaspi 1	0.72	0.68	0.39
Legaspi 2	4.57	1.14	4.17
Barangobong	3.92	0.72	2.12
San Vicente	3.76	0.716	2.15
Cabalitian	4.322	1.308	4.523
Callitang	0.128	0.492	0.057
Carmay	1.578	0.697	0.990
Tomana	1.152	1.054	1.092

Water Quality

The water quality indicators such as pH, Sodium, Sulfate, Chloride and Boron content shown in Table 3 were based on the laboratory analysis conducted by the BSWM on the water samples gathered from the different water sampling sites.

Table 3. Water quality indicators on water samples.

Study Site	pH	Na (ppm)	SO4 (ppm)	Cl (ppm)	B (ppm)
San Rafael	7.94	10.10	15.00	16.10	0.03
Legaspi 1	8.21	9.15	3.10	12.88	0.04
Legaspi 2	7.99	12.50	85.07	16.10	0.05
Barangobong	8.01	13.85	15.99	16.10	0.04
San Vicente	8.0	12.75	97.30	14.49	0.07
Cabalitian	7.71	17.00	146.10	12.88	*n*
Callitang	8.01	12.35	88.95	14.49	*n*
Carmay	8.37	13.85	75.65	12.88	*n*
Tomana	7.56	18.20	98.74	16.10	*n*

n – Not detected

a) pH

The pH is a measure of water acidity or alkalinity measured in pH units. The scale ranges from 0 to 14, with pH 7 representing neutral, water with a pH of 7 is neither acidic nor alkaline. As it progresses from pH 7 to pH 0, water becomes increasingly acidic; from pH 7 to pH 14, water becomes increasingly basic (alkaline). Water pH is easy to determine and provides useful information about the water's chemical properties. A very high or very low water pH can be a warning that you need to evaluate the water for other constituents. Water with a pH outside the desirable range must be carefully evaluated for other chemical constituents. The normal pH range for irrigation water is from 6.0 to 9.0. Table 3 shows that this nine tributaries with the pH values from 7.56 to 8.37 are within the normal range which means that the water in this tributaries were suitable for irrigation purposes.

b) Sodium (Na)

The sodium cation is often found in natural waters due to its high solubility. Irrigation water with a high level of sodium salts can be particularly toxic. Sodium in irrigation water can be absorbed by roots and foliage, and foliar burning can occur if sufficient amounts accumulate in leaf tissue. Assessment of sodium content is necessary while considering the suitability for irrigation.

ISSN 2599-4646 (Print) www.psurj.org/jonas ISSN 2599-4654 (Online)

The nine tributaries with the Sodium content values from 9.15 to 18.20 ppm are within the normal range of 0-50 ppm as shown in Table 3.

c) Sulfate (SO4)

Sulfate (SO4) is relatively common in water and has no major impact on the soil. Irrigation water high in sulfate ions reduces phosphorus availability to plants.

Table 3 shows that the nine tributaries with the Sulfate content values from 3.10 to 146.10 ppm are below the normal range of 400 ppm.

Sulfate is measured in irrigation water to indicate possible deficiency problems. If the concentration is less than about 50 ppm, supplemental sulfate may need to be applied for good plant growth [13].

d) Chloride (Cl)

Chlorides are found in all natural waters. It is said to be the common toxicity in the irrigation water. It is necessary for plant growth in relatively small amounts. Irrigation water with chloride content greater than 350 ppm is toxic when absorbed by roots, while chloride content greater than 100 ppm can damage sensitive ornamental plants if applied.

The nine tributaries with the Chloride content values from 12.88 to 16.10 ppm are below the normal range of 350 ppm as shown in Table 3.

e) Boron (B)

Boron is an essential element to the plants. It is needed in relatively small amounts and if the amount is greater than needed it becomes toxic. Surface water rarely contains enough boron to be toxic [14].

Table 3 shows that the nine tributaries with the Boron content values from 0 (not detected) to 0.07 ppm are below the normal range of 0.75 mg/l.

For surface water, boron is not detectable lower than the detection limit of 0.02 ppm [15]. Boron concentration in river was to decrease from upstream to downstream [16].

Other Observations

Dumping of garbage along the Agno River was observed which may cause water quality deterioration in the future. It is relatively comparable on the study at Sapang Baho River wherein it generally signifies that there is an input of organic pollution both from domestic solid and liquid wastes and solid wastes [10].

CONCLUSION AND RECOMMENDATION

Based on the results and findings of this study, water quality indicators and the water discharge at the study sites are all safe to use for irrigation. The pH of the water samples tested is within the normal range from 6.0 to 9.0. Amounts of sodium are within the optimum range of 0-50 ppm. Detected amounts of sulfate are too low to exceed the optimum amount of 400 ppm. Chloride contents of the water samples were below the normal range of 350. Boron content is not detected in all the water samples tested. Dumping of garbage along the sides of Agno River was observed which may cause water quality deterioration in the future. Thus, the Clean Water Act and Solid Waste Management must be strictly implemented.

Water quality analysis in Agno River and proper monitoring is recommended to be done monthly to determine the changes or any detrimental ills that may affect the irrigation water and may have adverse effect on agricultural crop performance.

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