Water Analysis of Cotabato City Rivers and its Implication to Human and Aquatic Life

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Abstract

This study aimed to determine the physico-chemical and biological characteristics of the rivers in Cotabato City namely Rio Grande de Mindanao along Quirino Bridge and Matampay Bridge, Rio Grande de Tamontaka, and Esteros river. Specifically it determined the physico-chemical characteristics of the river in terms of depth, dissolved oxygen, turbidity, biological oxygen demand (BOD), dissolved oxygen (DO), temperature, total suspended solid, salinity and pH. It also determined the level of coliform bacteria contamination in the river. Furthermore, it described the profile of the community along Cotabato rivers and their housing conditions/ in terms of number of member per household, occupation, annual income of households, religion and tribal affiliation. Moreover, it listed the the uses of the rivers by the residents and the water borne diseases afflicting the household members in the last three years. Finally, it identified the impact of the physico-chemical and biological characteristics of the rivers to aquatic organisms and human health. This study employed a descriptive-quantitative research design with survey, key informant interview and laboratory analysis as the main source of data. Supplementary data from the barangay were drawn such as: number of households and water borne diseases afflicting household members. Water analysis was done to determine the physico-chemical and biological characteristics of the river. The study revealed that the physico-chemical and bacteriological characteristics of Cotabato city Rivers conform with the criteria set by the EMB for class C rivers. Class C rivers are those suitable for fisheries, recreation and industrial use (after treatment). Bacteriological analysis of the rivers showed that these are contaminated with fecal coliform bacteria, that may be attributed to direct disposal of human wastes. Therefore, the rivers are not safe for household use.

1. Introduction

Cotabato City is the catchment basin of Ala River and Rio Grande de Mindanao. The Esteros and Tamontaka river serve as drainage and streamline system coming from the various areas of the city and nearby provinces. Both are tributaries of the Ala River. On the other hand, Rio Grande de Mindanao along Delta bridge receive large portion of water coming from the provinces of Bukidnon, Cotabato, Maguindanao and Sultan Kudarat. These rivers flow towards the Illana Bay.

In 2007 up to the present, flood has been a constant challenge to the residents of Cotabato City especially those living along these rivers. Due to the flood, residents have been displaced, properties were damaged and health became compromised. National and local government agencies and non government organizations collaborated to address these pressing conditions. Moreover, flooding contributes further siltation of the rivers thus aggravates the flow of water to the residence. However the solution of dredging the river was considered to be temporary rather than a long term solution. At present, more effective solution to the problem is still looked into. Aside from siltation, the rivers may clog due to the presence of voluminous water hyacinth that were brought about by the water coming from the nearby place hence it worsens the flooding of the city.

Water is the most indispensable substance for human daily life and survival. The residents along the rivers of Cotabato City utilize the river as source of water for their daily consumption.

They use it for bathing, personal and household purposes not considering if the water is safe to use. Moreover, it can be observed that several garbage including human wastes are thrown or disposed to these rivers. Most likely, the water may become contaminated with coliform bacteria which may lead to health problems. Since there is no updated data on the physico-chemical and bacteriological analyses of the waters of these rivers, this study must be conducted.

The findings of the study may be useful for the Department of Environment and Natural Resources, the Department of Interior and Local Government, and the Department of Health in crafting policy in line with maintenance of the river and keeping health and sanitation of the communities living along the rivers. This may also serve as baseline data which will be useful for future researches.

This study aimed to determine the physico-chemical and biological characteristics of the rivers in Cotabato City namely Rio Grande de Mindanao along Quirino Bridge and Matampay Bridge, Rio Grande de Tamontaka, and Esteros river. Specifically it sought to answer the following:

1. What are the physico-chemical and biological characteristics of the river in terms of:
   a. Depth
   b. Turbidity
   c. Temperature
   d. Salinity
   e. pH
   f. dissolved oxygen
   g. biological oxygen demand (BOD)
   h. total suspended solids
   i. coliform bacteria
2. What is the level of coliform bacteria contamination in the river?
3. What is the profile of the community along Cotabato rivers and their housing conditions/ in terms of:
   a. Number of member per household
   b. Occupation
   c. Annual income of households
   d. Religion
   e. Tribal affiliation of the parents
4. What are the uses of the rivers by the residents?
5. What are the water borne diseases afflicting the household members in the last three years?
6. What are the impact of the physico-chemical and biological characteristics of the rivers to
   a. Aquatic organisms
   b. Human health

2. Methods

Data Collection Techniques

This study employed a descriptive-quantitative research design with survey, key informant interview and laboratory analysis as the main source of data. Supplementary data from the barangay were drawn such as: number of households and water borne diseases afflicting household members. Water analysis was done to determine the physico-chemical and biological characteristics of the river.

Data Collection Tools

An interview guide questionnaire was developed and presented to the university research committee panel for approval. It generated the following data: a) the socio-economic profile of the respondents b) use of the river water and c) health profile of the households living along the rivers. Water samples from the identified rivers were analyzed to determine their physico-chemical and biological characteristics..

Respondents and Study Sites

The respondents of the study were the head of the family or any responsible member of the household. The respondents were identified from the barangays which are situated along the rivers. Barangays covering the households along the areas of Quirino Bridge (Poblacion 7), Matampay (Poblacion), Tamontaka (Tamontaka Mother Barangay, Tamontaka 2), and Esteros (Tamontaka 1), were included in the study. The sample size and study sites were shown below:

Table 1. Distribution of Respondents by Area

Name of River	Number of Respondents
Quirino	36
Matampay	27
Tamontaka	24
Esteros	53
TOTAL	**140**

Water sampling was done in three selected station sites per river. Sampling stations were those which were thickly populated, accessible. The point of reference of the sampling stations were the Quirino , Tamontaka , Matampay and Esteros bridges.

3. Findings

1. The physico-chemical and biological characteristics of the river

a. Depth **:** The depth of the rivers ranges from 45.0 – 53.7 m. The river along Esteros is the most shallow (29.4 m) while the deepest is along Quirino (53.7m).

b. Temperature: Water temperature was measured *in situ* at 9 -10 AM. The water temperature of the four rivers range from 29–30 ^{0}C

c. pH: The pH of the rivers range from 7.35 – 7.54 which is considered to be slightly alkaline

d. TSS : Tamontaka river has 18mg/L total suspended solids, Rio Grande has 28 mg/L, Esteros has 37 mg/L, and Matampay has 39 mg/L. It shows that Matampay river has the highest TSS and Tamontaka has the lowest.

e. Turbidity: The turbidity value of Matampay river is 40.8 NTuS, Esteros with 10.4 NTuS , Quirino with 5.7 NTuS and Tamontaka with 1.2 NTuS . water. Among the four rivers, Matampay river is most turbid and Tamontaka is least turbid.

f. Salinity: The rivers along Quirino and Matampay have the salinity value of 0.2 ppt while Esteros and Tamontaka do not contain dissolved salts.

g. Dissolve Oxygen: The rivers have high DO values (Quirino, Matampay, Esteros and Tamontaka is 6.23 mg/L, 5.9mg/L, 5.0 mg/L, and 6.06 mg/L respectively).. This means that there is adequate amount of oxygen necessary to support aquatic life.

h. Biological Oxygen Demand: TheBOD values of the rivers show that these rivers are not considered to be polluted The BOD values of Quirino, Matampay, and Esteros rivers is 3.33 mg/L while in Tamontaka river is 3.0 mg/L.

i. Coliform bacteria: Coliform bacteria are present in all water samples.

2. The level of Coliform Bacteria Contamination in the River

Total coliform and fecal coliform bacteria values of the water samples showed high contamination with fecal wastes.

3. Profile of the Community Along Cotabato Rivers and their Housing Conditions

a. Number of member per household: The largest proportion of families (61%) with number of children between1-4 and those with 5-9 children compose 23% of the population. The mean household size is 6.

b. Occupation: The sikad driver (20%) employs the largest population of the respondents followed by fishermen (18.6%) and sari-sari store owners/ sidewalk vendors (17.1%) respectively.

c. Annual income of households: Majority of the respondents are living below poverty line since most (57.9%) have a family monthly income of P3000 and below and only (1.4%) have family monthly income of P51000 and above.

d. Religion: Majority of the respondents (82.9%) are Islam as their religion, 13.6% are Catholic and 3.6% are Non-Catholic.

e. Tribal affiliation: Most of the respondents (82.9%) are Maguindanaons.

4. Uses of the rivers by the residents

Majority of the respondents (57.9%) used the river for washing their clothes and dishes, 50.7% use them for bathing and 1.4% for drinking.

5. Water borne diseases afflicting the household members in the last three years

The common diseases encountered include diarrhea (76%), ascariasis (37 %), cholera (22%) typhoid fever (21%), and amoebiasis. These gastrointestinal diseases can be associated to poor hygiene and sanitation. It can also be supported by the type of toilet facilities as well as their personal hygiene and environmental sanitation.

7. Impact of the physico-chemical and biological characteristics of the rivers to

a. Aquatic organisms

Temperature impacts the rates of metabolism and growth of aquatic organisms, rate of plants' photosynthesis, solubility of oxygen in river water, and organisms' sensitivity to disease, parasites, and toxic materials. At a higher temperature, plants grow and die faster, leaving behind matter that requires oxygen for decomposition.

Extremes in pH values can make a river inhospitable to life. Low pH is especially harmful to immature fish and insects. Acidic water also speeds the leaching of heavy metals harmful to fish.

High TSS value indicates poor water quality because it influences the turbidity of the water. The high TSS value may be due to the effects of sand and gravel quarrying activity, and runoff from denuded forests and agricultural lands. Turbidity affects the penetration of light in water. If the water is turbid it decreases the amount of light to penetrate the water thereby slowing the photosynthetic process which in turn can lower the production of dissolved oxygen.; low visibility which will affect the fish's ability to hunt for food; clog fish gills, prevent development of egg and larva. Moreover, turbid water may not also be suitable for washing, bathing and other household use.

Dissolved Oxygen (DO) is the amount of oxygen that is dissolved in water. It is one of the water quality parameters used as an indication of how polluted the water is and how well the water can support aquatic plant and animal life. Low DO level may be found in areas where organic materials are decaying as bacteria require oxygen to decompose organic waste thus, depleting the water oxygen. Areas near sewage discharges usually have low DO levels due to this effect. A higher dissolved O_2 level usually indicates better water quality. DO is needed for fishes to respire and perform metabolic activities. Low levels of oxygen is linked to fish kill incidents.

BOD is the rate at which organisms use oxygen in water or waste water while stabilizing decomposable organic matter under aerobic conditions. BOD parameters are used as measure of the organic strength of wastes in water. The greater is the BOD, the greater the degree of organic pollution.. The low BOD values of the rivers show that these rivers are not considered to be polluted.

BOD directly affects the amount of DO in rivers. The greater the BOD, the more rapidly oxygen is depleted. This means that less O_2 is available to higher forms of life. The consequences of high BOD are similar to those of low dissolved oxygen; aquatic organisms become stressed, suffocated, and die.

b. Human Health

Presence of coliform in rivers is an indication of possible bacterial contamination. Human wastes deposited directly into the river can attribute to its low water quality which indicates that it is unsafe for drinking and other household use

Conclusions

Cotabato City is endowed with four rivers that could be a natural resource that can provide various beneficial uses to it residents. With the turn of fast population increase, industrialization and advancement in agriculture and technology the quality of water in these rivers is affected.

The findings of the physico-chemical and bacteriological analyses of the water samples conform with the criteria set by the EMB for class C rivers. Class C rivers are those suitable for fisheries, recreation and industrial use (after treatment). However, based on the findings of the study, the community living along the rivers utilized them for household use such as washing, cooking, bathing and other activities. Bacteriological analysis of the rivers showed that these are contaminated with fecal coliform bacteria, that may be attributed to direct disposal of human wastes. Therefore, the rivers are not safe for household use

Recommendations

Results of the study provide insights and issues that need to be addressed to improve the water quality of the rivers. These are the following:

1. **Information Campaign**: One problem for non compliance to environmental concerns may be due to lack or insufficient information of the effects of pollution to the water environment as well as to the existing laws and guidelines in the place. This can be addressed by including information campaign as part of the water quality monitoring guideline.
2. **Monitoring of Water Quality**: Monitoring and updating of classification of rivers using DENR Administrative order no. 90-84 the revised water usage and classification/ water quality criteria.
3. **Biological Analysis**: Come up with inventory of Aquatic Fauna present in the rivers. Data on Fauna distribution and abundance is important to environmental monitoring and biodiversity.

With these concerns, it is imperative that Concerned Government Agencies will deal with the following:

1. Cotabato City Government and its Barangay Officials must initiate to increase awareness and active involvement of the residents in the community. They should come up with water quality objectives in their programs to provide bases for pollution control for carrying out specific measures for prevention control or reduction of water pollution and other adverse impacts on aquatic ecosystems. Proper sewage treatment should be designed to reduce contamination of the water in the rivers.

They should also strengthen enforcement by providing stiffer penalties for violations and standards.

Due to high levels o fecal coliforms found in the water, the City's Health Department must issue warnings about the health risks of bathing, drinking and other household uses of the water.

2. Department of Environment and Natural Resources should pursue the implementation of RA No. 9265: Clean Water Act (2004) which provides for a program and regulations for the abatement and management of water pollution from point to non point sources.

   These agencies must address pollution problems by formulation of various policies: such as monitoring and analysis, researches and capacity building among key stakeholders as part of the regular functions through the different programs implemented by the different concerned agencies. They should also craft policies in line with maintenance of the river and keeping health and sanitation of the communities living along the rivers.

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Active learning is an umbrella term that refers to several models of instruction that focus the responsibility of learning on learners. It is defined as instructional activities involving students in doing things and thinking about what they are doing (Bonwell and Eison, 1991). This provides an instructional environment where there is sufficient time for student interaction, sharing, clarification of ideas about science concepts where students restructure their existing knowledge.This study hoped to develop appropriate Active Learning and determine the effects of these lessons on the conceptual understanding of students.

The main objective of the study was to investigate the effect of active learning in the conceptual understanding of physics by college students. Specifically, the study aimed to answer the following questions:

1. What is the level of conceptual understanding of the students exposed to Active Learning and Lecture Method (a) prior to instructions; (b) after the instructions?
2. Is there a significant difference between the conceptual understanding of students in the experimental and the control group?
3. What are the types of conceptual changes in students when exposed to (a) Active Learning; (b) Lecture Method?
4. What are the levels of confidence prior to and after instructions of the students exposed to Active Learning and Lecture Method?
5. Is there a significant difference between the change in the level of confidence of students exposed to Active Learning and Lecture Method?
6. What are the students' conceptions on Electricity prior to and after Active Learning instruction?
7. What are the students' views on active learning?

2. Methodology

There were two groups of students who were involved in this research study. One group was the experimental group which was exposed to Active Learning. The Active Learning lessons were embedded in a constructivist learning cycle consisting of Orientation, Elicitation, Restructuring, Application and Review. In the orientation phase of the learning cycle questions were raised to direct the students in understanding of the concepts. Students are then asked to write their initial conceptions related to the questions during the Elicitation phase. Activities were done by the students in groups. This is the Restructuring phase. In the Application phase, students work on various problems individually. Students reflect on the activities they have done and wrote their journals in the last phase which is the Review phase.

Sample Active learning Lesson Plan

Lesson Title: Electric Charge and Electrostatic Force
Duration: 1.5 hours
Objectives: At the end of the period, students are expected to:

1. describe the interaction of materials when they are rubbed and brought close to each other.
2. predict and design experiment when other materials are rubbed and brought close to each other.
3. explain why rubbing objects make them attract or repel each other.
4. represent interaction of other materials and give reasons for such representation.
5. find pattern on a data presented from an experiment.

Procedure

Orientation: Students will be asked to do activity shown below:

Elicitation:

1. Observe and find a pattern: For the experiments that follow, you need two foam insulation tubes, a small piece of felt or wool, string, and plastic wrap. Suspend one tube from the string, as shown in the illustration. Before starting the experiments that follow, bring one end of tube 2 near one end of the hanging tube1. Is there any interaction? Now rub one end of each tube vigorously with different materials, as described below.

a. Bring the rubbed end of tube near the rubbed end of the suspended tube 1 and record in the table that follows the behavior of tube 1.
b. Identify patterns in these observations. Devise an explanation

1. Predict and Test: Assemble two long pieces of nylon (stocking work fine) and a plastic grocery bag. Design an experiment to test how pieces of nylon rubbed with the plastic bag interact with each other. Fill in the tables that follow to make prediction about the outcomes of your experiments based on the patterns that you found in Activity a. Design an experiment to test how nylon pieces rubbed with plastic interact.
   b. Predict the outcome of your experiment.
   c. Perform the experiment and then described the outcome.
   d. Was the reasoning leading to your prediction correct? Explain.

   3. Explain In the above activities you found a consistent pattern: Identical objects rubbed with a second material repel each other. The second material in turn attacks the object its rubbed. Think of a mechanism that might explain why rubbing objects makes them attract or repel each other.

   4. Test the explanation: Your friend Gaurang says that electric interactions are the same as the magnetic interactions because magnet also attract and repel each other. Consequently, he believes that when you rub objects, they became magnetized. Assemble a magnet on a swivel, two foam tubes, felt and plastic wrap. Design an experiment whose outcome will allow you to decide whether Gaurang is correct or whether rubbing objects makes them participate in a new type of interaction.

Describe an experimental set up to test the idea that rubbing causes materials to become magnetic (Gaurang's idea)

- your experiment based on Gaurang's idea.
- Perform the experiment and described the outcome.
- Make a judgment about Gaurang's idea based on the outcome.

5. Restructuring**:** Responses to every question are presented by the students by groups and discussed with the teacher as facilitator.

6. Application

Find a Pattern **:** Charles Coulomb used a torsion balance to measure the force that one charged ball exerts on another charged ball to find out how the force between two electrically charged objects depends on the magnitude of the charges and on their separation. Coulomb could not measure the absolute magnitude of the electric charge on the metal balls. However, he could divide charges in half by touching a charged metal ball with an identical uncharged ball. The table that follows provides data that resemble what Coulomb might have collected. Find patterns in the data and devise a mathematical relationship based on these observations. Use graph paper to help. Remember to decide which are the independent variables and which is dependent variable. Then analyze the changes in the dependent variables as you change only one independent variable at a time.

7. Review**:** Students were asked to write their learning and reflections on the process in their journal.

The Lecture Method Lessons were developed parallel to the Active Learning lessons were given to the control group. The parts of the lecture method lessons were the following: (a) motivation, (b) lesson proper, delivered through direct instruction, (c) problem-solving activities, and (d) post lecture discussion. The topics covered in the lecture method lessons were basically the same as the Active Learning Lessons. The main difference lies in the delivery of the lessons.

Sample Lecture Method Lesson

Title: Introduction to Electrostatic and Charges
Duration: 1.5 hours
Lesson Objectives: At the end of the lesson, the students will be able to
a. discuss the structure of an atom
b. define conductors and insulators

c. explain how materials may be charged
Lesson Procedure:
a) Motivation
1. Review of previous lesson.
2. Introduce to students the present lesson which is on Electrostatic and Charges
3. Inform students of the objectives of the lesson.
b) Lesson proper Lecture-discussion method on electrostatics and charges will be conducted.
c) Problem-solving activities: Students will work on some selected problems:

The validated Conceptual Test on Electricity was administered to both experimental and control groups before the start of the actual classroom research study. The test determined the students' level of conceptual understanding, their preconceptions on Electricity, and level of confidence. A parallel Conceptual Test on Electricity was administered to both groups after the completion of the lessons.

Quantitative and qualitative methods were utilized to analyze the data in order to address the research problems. In the qualitative analysis, the conceptual trace analysis to students' explanations in the pretest and posttest and journal analysis were used. Responses in the interview were also utilized in the qualitative analysis.

Interviews were conducted and the "Questionnaires on Student's View of Active Learning were administered to the experimental group after the Active Learning on Electricity. The students' views on Active Learning were determined through interviews and the questionnaire.To determine students' conceptual change of both AL and traditional lecture group, a conceptual trace analysis was performed.

7. Results

Students' Level of Conceptual Understanding

7.1 The level of conceptual understanding of both the experimental, the Active Learning (AL) and control, the Lecture Method (LM) groups prior to instructions was mostly in the Partial Understanding with Specific Misconception (P/M). Some students were classified under Specific Misconception (SM). This implied that the students' level of conceptual understanding before the instructions was characterized by poor understanding of the concepts on electricity. The distribution of students in the five levels of conceptual understanding prior to instructions likewise point to this same implication.

After the lessons were introduced to both groups, majority of the students were categorized under Partial Understanding with Specific Misconception **(**P/M) and there were few students under Partial Understanding (PU)**.** The level of understanding of students were raised to a higher level, the Partial Understanding (PU) and Partial Understanding with Specific Misconception (P/M) and no student was left in the level of Specific Misconception(SM) and No Understanding (NU) levels. Furthermore, both groups exhibited increases in the Sound Understanding category. The increase for the experimental group does not differ much with the control group. Both groups likewise exhibited the greatest decreases in the Specific Misconception category. All categories other than Sound Understanding for the experimental group had significant decreases in frequency. This indicates the effectiveness of both methods of instruction in improving students' level of conceptual understanding and that AL is just as effective in elevating the level of conceptual understanding to sound understanding as LM.

7.2. The mean gain scores of the experimental group was higher than that of the control group. However, statistically there was no difference between their mean gain scores.

7.3 . Results showed that the types of conceptual changes of students in both groups are classified into the following types: Partial

Understanding with Specific Misconception to Partial Understanding with Specific Misconception in the No change category. Forty percent of the population of students in the experimental and control groups remained with the Partial Understanding with Specific Misconception after taking lessons using active learning and the Lecture method.

It is good to note however, that 60 percent of the population of students in the experimental and control groups have elevated their conceptual understanding and thus falling under the Change for the Better category. The 60 percent all fall under semantic conceptual change with Specific Misconception to Partial Understanding with Specific Misconception, Specific Misconception to Partial Understanding and Partial Understanding with Specific Misconception to Partial Understanding categories.

7.4. In both groups, the students' level of confidence changed positively. Both the Active Learning group and Lecture Method group increased the level of confidence of students after instruction. However, the difference in the increase in the level of confidence between groups was not statistically significant.

7.5. Results showed that Students' Conceptions in the Active learning Lessons and the Lecture Method changed

7.6. Based on the questionnaire and interviews, results revealed that generally students have positive views towards the use of active learning in the classroom. The Active learning developed in them independent thinking, active participation in class allowing them to share their own ideas freely and a sense of responsibility. This learning environment further developed in them a higher degree of confidence. Students view Active Learning as a strategy that enhanced and gave a clearer understanding of the lessons and memorization of formulas. They claimed that AL enables them to develop a positive attitude towards Physics because it made the lessons interesting, corrected the notion that Physics is a difficult subject, encouraged them to study in advance, helped gain confidence in answering questions and made them want to learn more. They believed that changing the role of a teacher from a dispenser of knowledge to a facilitator of learning helps them become independent learners and responsible for their learning. The use of reflective journals, which is a part of AL, served as a means of communication with the teacher, a reviewer or lessons refresher, provided opportunities for sharing happy moments, helps students compare their prior knowledge with the new ones. Active Learning helped students improve their level of conceptual understanding by making concepts clearer and the lessons more meaningful to students thus helped bring about conceptual change. The students' imagination was enhanced by the active learning resulting in better understanding of the lessons.

8. Conclusion

Based on the findings of the study, the following conclusions were drawn.

8.1. Generally, the Active Learning is as effective as Lecture Method in increasing the level of conceptual understanding of college physics students, however, it was effective in improving their semantic conceptual understanding.

8.2 Generally, students have positive views towards the use of Active Learning in the classroom. This instructional material has developed in them independent thinking and a sense of responsibility in their learning and allowed them to actively participate in class and to share their own idea.

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