WATER QUALITY TESTING AND TREATMENT IN THE PROPOSED CPU WATER LABORATORY

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Abstract---*The impairment and progressive deterioration of water systems exposed to pollution in Region VI were not given importance because of the lack of water quality testing and treatment laboratory to monitor and correct them. It is because of this problem that CPU has come up with the plan of putting up a water quality testing and treatment laboratory to monitor and correct them. This paper contains the literature needed in the conduct of a water quality testing and treatment in the proposed water laboratory of Central Philippine University. This includes the measurable characteristics, compounds or constituents found in water which affect its quality; the physical, chemical and biological characteristics of wastewater and their sources; the proper sampling techniques for collection, preservation and transport of water samples; the different methods of water analysis; the treatments appropriate to the removal of various forms of water impurities; the basic principles on how to develop a monitoring program to monitor the quality of water and the requirements of a good laboratory operation and management.*

INTRODUCTION

Freshwater is increasingly becoming a scarce commodity in Western Visayas. Still a large number of people has limited or has no access to safe and clean water because of the fact that, the potential of the region's water resources have not been fully harnessed. The technology needed to handle this does not still exist. And given the current rate at which these resources are degraded, the realization of such potential may never come to pass. There is therefore a need to change the traditional notion of water as an abundant and free commodity to one which must be conserved and utilized wisely.

Region VI is so far considered the number one polluter in the whole Philippines based on the waste dumping category (Marquez, 1995). It is a terrible thing to find out that out of 957.74 ML of the region's generated wastes per year, 702.82 ML per year or 73.6% of it is just being dumped to the water courses without prior treatment. This environmental crime has been known to exist already in the 1980's. Large amounts of organic wastewaters primarily containing molasses,cane juice and malts from sugar mills and alcohol distilleries caused the deterioration of the rivers in the region (Environmental Management Bureau, 1990).

The general objective of this study is for the researcher to have enough background for the conduct of water quality testing and treatment. The specific objectives are to know and use the proper sampling techniques for collection, preservation, and transport of samples from the source to the laboratory in order to obtain reliable results, determine the extent of pollutant removal needed for safe disposal of the treated waste-water based on different water usage or classification, operate and maintain the equipment in the water testing laboratory and to apply the appropriate method for the treatment and removal of specific water pollutants.

This proposed laboratory is expected to perform more comprehensive water quality testing for all parameters suspected to exist at the present in surrounding waters of Region VI. It will be tasked to monitor the quality of public drinking water supply, the discharges of industrial effluents into municipal sewers, and the discharges of secondary treated effluents into small inland rivers surrounding the region. This can also be used to examine whether or not the municipal treatment plants and the industries are meeting the required quality for drinking water and for wastewater disposals.This proposed water laboratory will not only augment the existing services of the Department of Energy and Natural Resources but will be used for educational training of engineering students.

WATER QUALITY CHARACTERISTICS

The measurable physical characteristics are true color (the color which remains after any suspended particles have been removed); turbidity (the cloudiness caused by fine suspended matter in the water); hardness (the reduced ability to get a lather using soap); total dissolved solids (TDS); pH; temperature; taste and odor; and dissolved oxygen.

In general, the physical characteristics of water do not threaten public health, but they affect the aesthetic quality of the water and this determine whether or not people are prepared to drink it.

A number of chemicals, both organic and inorganic and including pesticides, are of concern in drinking water from the health perspective because some are toxic to humans and some either cause or are suspected of causing cancer. Some can also affect the aesthetic quality of water.

Inorganic chemicals in drinking water usually occur as dissolved salts such as carbonates, chlorides, etc., attached to suspended material such as clay particles, or as complexes with naturally-occurring organic compounds. Their presence may result from natural leaching into source waters from mineral deposits; human activities; or corrosion of pipes and fittings. Some are deliberately added to drinking water for disinfection, clarification or public health (e.g. fluoride). By-products of disinfection are the most commonly found organic contaminants.

The most common and widespread health risk associated with drinking water is contamination, either directly or indirectly, by human or animal faeces, and with the micro-organisms contained in the faeces. Drinking contaminated water or using it in food preparation may cause diseases like mild gastro-enteritis, diarrhea, dysentery, hepatitis, cholera or typhoid fever.

Water Quality Criteria

Water quality may be defined as the assessment of the physical and chemical properties of material dissolved or suspended in water.

Water quality criteria may be defined as the scientific information on which decisions or judgements are based about the suitability of water quality for a designated use (Hart, 1980). They are used in identifying if the quality of water are suitable for the values and uses for which they are identified as requiring protection. They are the quantitative (or qualitative) data that predict the chance or magnitude of the effects of a contaminant on a defined receptor under specific environment. These criteria are described in terms of water quality indicators.

There are two main uses of water quality criteria according to Hart (1980): in the development of standards and in assisting the development of water quality management strategies. Criteria are the main inputs of scientific information in the setting of standards. Without this information, standards would be arbitrary and carry little guarantee of adequate environmental protection.

Water quality guidelines translate the criteria into a form that can be used for management purposes. Standards are what guidelines become when compliance is enforced by law.

Water Quality Indicators

Indicators are variables that indicate the presence or condition of phenomena. They reflect the state of any aspect or component of the environment. They act as signs or as early warnings of a problem because they highlight the status quo and what could occur in the future.

The method of selecting the indicator varies with the characteristics of the component, but they all share one requirement. The indicator must respond to changes in the component it is scaling in such a manner that it accurately reflects the magnitude of these changes. Appropriate water indicators have been developed to facilitate in giving direct outcomes.

Water Sampling

The objective of sampling is to collect a portion of material small enough in volume to be transported conveniently and handled in the laboratory while still accurately representing the material being sampled. This objective implies that the relative proportions or concentrations of all pertinent components will be the same in the samples as in the material being sampled, and that the sample will be handled in such a way that no significant changes in composition occur before the tests are made.

It is essential to ensure sample integrity from collection to data reporting. This includes the ability to trace possession and handling of the sample from the time of collection through analysis and final disposition.

The type of sample container used is of utmost importance. For samples containing organics, avoid plastic containers except those made of fluorinated polymers such as polytetrafluoro ethylene (TFE). For samples containing volatile organics, use glass containers because some compounds in it may dissolve into the walls of plastic containers or may even leach substances from the plastic.

Methods of preservation are relatively limited and are intended generally to retard biological action, to retard hydrolysis of chemical compounds and complexes, and reduce volatility of the constituents. They are generally limited to pH control, chemical addition, refrigeration and freezing. The preservation procedure for the different parameters are given in Table 1.

Water Monitoring

The broad objectives of water monitoring include the conservation of water quality and quantity to assure an adequate supply of water suitable in quality for both public and industrial uses and for the maintenance of fish and wildlife.

Water monitoring is the continuous sampling, measurement, and analysis of the quantity and quality of various liquid streams. These streams may include wastewater streams or plant effluents; water courses such as rivers, lakes, and estuaries; ground water; recirculated streams such as cooling water; power plant streams such as boiler feedwater condensate; or process effluents (Hamilton, 1978).

Monitoring is no longer a solely voluntary procedure. In other countries, monitoring is a legal requirement of a regulatory agency for the prevention, reduction, and elimination of pollution. These include establishing, equipping, and maintaining a water quality monitoring system for all waters. Owners and operators of any point sources are now required to establish and maintain records, to make reports, and to install, use, and maintain monitoring equipment and methods in such a manner as the regulatory agency should provide. Point-source discharge into waters is prohibited unless the discharge is authorized by permit. A substantial monitoring program may be necessary to provide information required by the permit. Such a monitoring system would also be able to provide data to answer inaccurate accusations of harmful or illegal wastewater discharges. Adequate monitoring records can document that a facility was operating in conformance with permit requirements during any particular period of time.

A monitoring program has two main components: System performance monitoring is a wide-ranging assessment of the quality of water in the distribution system and as supplied to the consumer. The data are used for assessing compliance with the guidelines or agreed standards of service and, if necessary, as a trigger for corrective action to improve water quality. Operational monitoring is used to check that the processes and equipment that have been put in place to protect and enhance water quality are working properly. The data are used, if necessary, as a trigger for immediate short-term corrective action to improve water quality, but they are not used for assessing compliance with the guidelines or agreed standards of service.

Water Quality Tests

Water is analyzed to determine its suitability for drinking, cooking, washing and other lesser domestic purposes while wastewater is analyzed to determine its suitability for discharge or the degree of treatment required to render it acceptable for discharge.

The type of test to be performed depends upon the degree of accuracy required, the use of the data and the use of the water. The types of test used on water and wastewater can be broadly classified as:

* Tests for gross pollution such as BOD, COD, suspended solids, ammonia, and grease. These are used extensively for wastewaters.
* Tests for appearance and aesthetic acceptability of waters, such as taste, odor, turbidity and color. These tests are used widely for water supplies.
* Microbiological tests, which are used mainly for detecting indicator organisms in water supplies and effluents.
* Tests for toxins.
* Tests for materials that are a health risk.
* Tests which determine suitability for incidental uses. These are tests which assess corrosivity on the basis of dissolved gases, pH and dissolved salts.
* Operational tests used to check plant performance.

The following are the usual water quality tests performed in the water laboratory, namely gravimetric, titrimetric, colorimetric, potentiometric, general solids, spectroscopic, chromatographic and the like. The method of analysis for all designated parameters are also available in Table 1.

WATER/WASTEWATER TREATMENT METHODS

The most important objective of water treatment is to produce a water that is biologically and chemically safe for human consumption while that of wastewater treatment is to produce an effluent that can be discharged without causing serious environmental impacts.

The commonly used water treatment methods are either physical operations or chemical processes. Biological processes are not suitable in situations where contaminant concentrations are low.

Processes and operations used in wastewater treatment are similar to those used in water treatment except for biological methods.

The principal use of biological treatment is for the removal of easily biodegradable organic compounds, although biological processes are also used for removal of nitrogen and phosphorus in some situations.

In selecting treatment processes for particular applications, the general physical form and the chemical and biological nature of the impurities to be removed are of great importance. Treatments appropriate to the removal of the various forms of impurity are similarly classified under broad headings of physical,chemical and biological processes.

Laboratory Management

With the adoption of more stringent standards for water quality, the importance of laboratory operation and the generation of credible data increases. Competent management is essential to bring about reliable laboratory performance to ensure precise and accurate analysis of samples. Good laboratory management requires that guidelines are made available and procedures are implemented for : inventory of chemicals and equipment; maintenance of equipment and instruments; purchasing; quality; safety; staff and, waste management, and documentation of all methodologies used for analysis of samples.

CONCLUSIONS AND RECOMMENDATIONS

A sampling program to be effective should consist the following steps: (1) a review of existing data (effluent, water quality, hydrologic land use, geology, soils, vegetation); (2) selection of sampling locations (the number of stations is dependent upon the available resources); (3) defining a sampling procedure; (4) selecting significant parameter to be measured; (5) establish a sample analysis procedure; (6) based on available sample results, prepare control charts to help determine minimum sampling interval during highly varying flow conditions; (7) assess the performance (apply statistics); and (8) reporting.

Sample collection and field measurements must be done by appropriate trained staff equipped with the needed sampling equipments and instruments for the specific analysis to be made. The results of any analysis are of value only if the sample is known to represent accurately the water or wastewater being sampled. Data verification should be performed at several levels: (1) field sampling requirements; (2) field measurement; (3) sample preservation and transport; (4) laboratory storage and analysis; (5) regular check of data such as date, site, time, range etc. on entry to the computer, and (6) manual checking of results after entry to the computer.

The number of samples to be taken and the time and exact place of sampling depends on the importance of the analysis, the accuracy required, and the resources available but skilled judgement will be valuable and there may even be a case for simple cost-benefit analysis. Thus, the whole sampling technique will depend upon what is being sampled, why it is being analyzed, and what constituents are to be determined. The type of water quality test to be performed depends upon the degree of accuracy required, the use of data and the use of water.

The choice of treatment processes for any particular application depends on the quality of the raw water, the required quality of the treated water and the economic resources available to pay for both the capital and operating costs of such treatment.

The type and extent of treatment required depends on the nature and degree of the quality deficiences to be corrected. If the water conforms to the desired standards for both chemical content and appearance but subject to occasional minor bacterial contamination, it requires only disinfection. If the raw water is frequently either turbid or coloured, it requires more extensive treatment. Water which contain excessive amounts of either dissolved salts or toxic materials require expensive treatment.

Availability of guidelines and implementation of procedures for inventory of chemicals and equipment, maintenance of equipment and instruments, purchasing, quality, safety, waste management and documentation of all methodologies used for analysis and samples are needed in a good laboratory management.

Further research is recommended for the following: a) Information on what happens to waste in receiving water and their effects on the water, particularly wastes that cause tangible changes in the water itself or significantly affect successive uses; and b) A methodology for keeping track of quality changes and quickly computing the concentration of pollutants at all relevant points of use, as a function of a variety of conditioning factors. The latter includes waste loads at particular outfalls, biological, chemical, and physical conditions and volume of stream flow.

PARAMETER	CONTAINER	MINIMUM SAMPLE SIZE (in ml.)	PRESERVATION	MAXIMUM STORAGE RECOMMENDED	METHOD OF ANALYSIS
Acidity	P, G (B)	100	Refrigerate	24 h	Titration Method
Alkalinity	P, G	200	Refrigerate	24 h	Titration Method
Biological Oxygen Demand (BOD)	P, G	1,000	Refrigerate	6 h	DO Measurement
Carbon, Organic Total	G	100	Analyze immediately; or refrigerate and add HCl to pH<2	7d	Combustion Infrared Method
COD	P, G	100	Analyze as soon as possible, or add H_2SO4 to pH < 2; refrigerate	7d	Dichromate Reflux
Chlorine, Residual	P, G	500	Analyze immediately	0.5 h	Amperometric Titration
Chloride*	P, G	100	None required	6 months	Spectrophotometric
Color	P, G	500	Refrigerate	48 h	Spectrophotometric
Conductivity	P, G	500	Refrigerate	28 d	Electrometric
Cyanide, Total	P, G	500	Add NaOH to pH > 12, refrigerate in dark	24 h if sulfide is present	PreliminaryDistillation/titrimetric/colorimetric
Total Coliforms* Faecal Coliforms	Sterile glass	250	If chlorine is present add 0.1 ml of 10% (w/v) sodium thiosulphate per 100ml of sample. Cool to between 1-4°C	6 h	Membrane Filtration
Hardness	P, G	100	Add HNO_3 to pH<2,	6 months	EDTA Titrimetric Computation
Metals (General)	P(A), G(A)	2,000	For dissolved metals filter immediately, add HNO_3 to pH<2 refrigerate	6 months	
Chromium IV	P(A), G(A)	300	Add HNO_3 to pH<2	24 h	Colorimetric
Mercury	P(A), G(A)	500	4°C, refrigerate	28 d	Flame AAS
MBAS (Methylene Blue Active Substance	G	250	Add chloroform to 0.2% (V/V) of sample and store at 4°C	48 h	Colorimetric
Nitrogen: Ammonia	P, G	500	Analyze as soon as possible or add H_2SO4 to pH<2, refrigerate	7 d	Nesolirization
Nitrate	P, G	100	Analyze as soon as possible or refrigerate	48 h	UV Spectrophometric
Nitrite	P, G	100	Analyze as soon as possible or refrigerate	none	Colorimetric
Organic Kjeldahl	P, G	500	Refrigerate; add H_2SO4 to pH<2	7 d	Macro-Kjeldahl Method
Odor	G	500	Analyze as soon as possible or refrigerate	6 h	Threshold Odor Test
Organic Compounds: Pesticides	G(S), TFE-lined	1,000	Refrigerate. add 1000 mg ascorbic acid/L if residual chlorine present	7 days until extraction; 40 days after extraction	Gas Chromatographic
Phenols	P, G	500	Refrigerate, add H_2SO4 to pH<2	7 days	Colorimetric: Direct Photometric Method
Oxygen Dissolved Electrode	G, BOD bottle	300	Analyze immediately	0.5 h	Electrometric
Winkler	G,BOD bottle	300	Titration may be delayed	8 h	Iiodometric (Azide Modification)
pH	P, G	100	Analyze immediately	0.5 h	Electrometric
Phosphorus	G(A)	100	For dissolved phosphate filter immediately; refrigerate	48 h	Digestion: Nitric Acid Sulfuric
Silica	P	150	Refrigerate, do not freeze	28 d	Colorimetric: Hetropoly Blue Method
Residues: * Total Nonfilterable (Suspended Solids)	P	1,000	None required	Analyze as soon as possible but within 24 hrs.	Volumetric
Total Filterable (Total Dissolved Solids)	P	1,000	Store at 4°C	Analyze as soon as possible but within 24 hrs.	TDS Dried @ 180°C
Sulphate	P, G	150	Refrigerate	28 d	Gravemetric
Sulphide	P, G	100	Refrigerate; add 4 drops 2N zinc acetate per 100 mL; add NaOH to pH>9	28 d	Methylene Blue Method
Taste	G	500	Analyze as soon as possible, refrigerate	24 h	Flavor Threshold Test
Temperature	P, G	—	Analyze immediately	Stat	
Turbidity	P, G	—	Analyze same day; store in dark up to 24 h, refrigerate	24 h	Nephelometric

Notes:

Refrigerate = storage at 4°C, in dark
P = plastic (polyethylene or equivalent)
G = glass
stat = no storage allowed

G(B) = glass, borosilicate
G(A) or P(A) = rinsed with 1 + HNO_3
G(S) = glass, rinsed with organic solvents
*Taken from EPA Victoria Report No. 95/79, rest from Standard Methods (18th ed.)

Table 1. Preservation and Method of Analysis for the Different Monitoring Parameters

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