Testing Instrument For Water Quality and Drinking Water Using Oxidation and Electromagnetic Methods (Case Study: Local Water Company at Bangka Barat)

V Luvita, N T Eka Darmayanti, G Zaid and D Setyarini
Research Centre for Metrology, Indonesian Institute of Science, Serpong, Indonesia

Email: veny.susanto@gmail.com

Abstract. Safe clean water, especially for consumption purposes, is needed by the humans. Various regulations on water safety standards have been developed and implemented by each country, including Indonesia Regulation of the Minister of Health Number 492/MENKES/PER/IV/2010 concerning Water Quality Requirements; SNI 01-3553 2006 on Drinking Water in Packaging and Government Regulation of the Republic of Indonesia Number 82/2001 on the Management of Water Quality and Control of Water Pollution. Some parameters of physics, chemistry, biology and radioactivity are the benchmarks of water security. Raw water treatment for clean water and drinking water has been done using oxidation and electromagnetic methods. Both of these methods have been tested in local water company (PDAM) at Bangka Barat which has problems with high organic content, the amount of heavy metal content Fe and Mn that exceeds the threshold above normal and high acidity level. Test results after processing show physical and chemical parameters that meet the criteria of water quality and drinking water requirements in accordance with regulations set by the government. Other important things besides meeting the health requirements are also the quality assurance of the measuring instrument used to test the physical and chemical parameters. This measurement traceable to International System of Units through Research Centre of Metrology- Indonesian Institute of Science.

1. Introduction
Water as a vital source of life is a very important and fundamental resource for the survival of living things in this world. Cities, nations and civilization have grown near rivers. Satisfactory water supply (adequate, safe and accessible) should be available to all living creatures of humans, animals and plants. In human life, water is widely needed in all aspects such as for consumption, crop irrigation, industry, power generation and much more. Water is well known as a “universal solvent” which means that many kinds of materials can dissolve or wash away in it. This character also makes it easy for water to be polluted with things that are dangerous or harmful. The problem of polluted water is very serious and can affect to the quality life of mankind and other living things as well [1-3]. Therefore, water must be utilized wisely so that sustainability of clean water and the ecological balance can be maintained and utilized continuously by our future generations.
Safe clean water is essential to the realization of basic human rights so that an effective policy in regard to clean water supply is required. Since the diseases related to drinking water contamination
become a major burden of human health, therefore every effort should be made to achieve the highest quality of drinking water. Interventions to improve the quality of drinking water and access to safe drinking water will give real benefits to good health for the society. Access to safe drinking water is essential to develop programs at the national, regional and local levels. In some areas, it has been shown that investments in water supply and sanitation can result in net economic benefits, as the reduction of adverse health effects and health care costs are greater than the cost of intervening [4-5]. Experiences also show that interventions in improving access to clean water greatly benefit the poor, both in rural and urban areas, and can be an effective part of poverty alleviation strategies.

2. Experimental Section
Water quality testing is essential for identifying pollution problems that occur, ensuring that water is proper for intended use, ensuring that the water to be consumed is safe and also for evaluating the effectiveness of the water treatment system. In recent day, environmental issues related to environmental pollution have also been the concern of the community both in national and international scope [6]. Law enforcement is firmly enforced for companies that cause environmental pollution. It is intended to protect the environment and to preserve the balance of the ecosystems. Thus, the water quality test result data must be valid and acceptable to all interested parties, so that appropriate policy or decisions can be taken as water is a very important natural resource and is needed by all living creatures.

Metrology both in physics and chemistry are expected to play a strategic role in overcoming water problems, and become part of the clean water supply solution for mankind. It can be done by developing techniques / measurement methods and traceability needed for determining water quality, estimating the water balance and developing methods for water quality monitoring and water quality improvement.

The World Health Organization (WHO) has published international norms on water quality and human health in the form of guidelines that has been used as the basis of regulation and standard setting worldwide. In Indonesia, there are several regulation on regard to water quality including Regulation of Minister of Health of Republic Indonesia No. 492/MENKES/PER/IV/2010 concerning Drinking Water Quality Standards; SNI 01-3553 2006 on Bottled Drinking Water and Government Regulation of the Republic of Indonesia No. 82 year 2001 on the Management of Water Quality and Control over Water Pollution. There are several of the physical, chemical, biological and radioactivity parameters that set out in most regulations as shown in the Table 1.

| Table 1 Parameters that affect the quality of clean water |
|---------------------------------------------------------|
| **Parameter**               | **Physical** | **Chemical** | **Microbial** | **Radiological** |
| Total hardness             | Inorganic: Arsenic, Fluoride, total | Coliform | Gross-A |
| (TDS)                      | Chrom, cadmium, nitrite, nitrate, cyanide | E-coli | Gross-B |
| Temperature                | Selenium | Organic: Detergent, pesticide | TOC, pesticide |
| Electrolytic conductivity  | | | |
| pH                         | | | |

In this study a prototype will be developed to improve water quality in a physical-chemical manner using electromagnetic resonance methods. This tool has a resonance tube which is equipped with a coil and an electric pulse generator to produce a magnetic field so that it can resonate with water molecules.
This prototype to improve water quality in a physical-chemical way works by giving resonance treatment to hydrogen atoms physically to water molecules. The magnetic resonance method in this tool works by utilizing the behavior of protons and the molecular bonds contained in water [7-8]. The behavior of protons (including those found in water molecules) due to the influence of certain static magnetic fields (on this device utilizes the earth's magnetic field) which, if then disturbed by other magnetic fields that have a certain frequency, where the direction of both magnetic fields is perpendicular or not mutually parallel, the Larmor Precession with a certain frequency (Larmor Frequency) and the duration of the resonance is also specific [9]. In water molecules mixed with other liquid or solid materials, the mixing material if it has a proton will also resonate with a certain resonance frequency and duration. Such events can be found in theories related to Nuclear Magnetic Resonance or Proton Magnetic Resonance. With this kind of treatment the molecules contained in water will become clusters, so that groups that are reactive (pure water) become larger and not blocked by mixing materials [10].

3. Result
The results of research conducted using the system created shows that there is a decrease in the value of the measure parameters. This shows the quality of treated water is getting better. In the treatment process of ex-mine lake water, it was found that all the measured mineral parameters had decreased and were degraded by the presence of oxidation and electromagnetic processes.

Table 2. The results of the Analysis of the Raw Water Measurement Laboratory in Bangka Barat PDAM before and after processed using AOPs and EWT

| No. | Parameters          | Unit     | Experiment | Before  | After |
|-----|---------------------|----------|------------|---------|-------|
| 1   | Conductivity        | μS/cm    |            | 16800   | 5500  |
| 2   | Ammonia (NH\textsubscript{3}-N) | mg/L     |            | 0.265   | 0.312 |
| 3   | Barium              | mg/L     |            | < 0.005 | < 0.005 |
| 4   | Iron (Fe)           | mg/L     |            | 6.8     | 2.9   |
| 5   | Chloride (Cl\textsuperscript{-}) | mg/L     |            | 3600    | 887.5 |
| 6   | Cobalt (Co)         | mg/L     |            | < 0.004 | < 0.004 |
| 7   | Manganese (Mn)      | mg/L     |            | 0.65    | 0.11  |
| 8   | Nitrate (NO\textsubscript{3}-N) | mg/L     |            | 15.8    | 2.15  |
| 9   | Nitrite (NO\textsubscript{2}-, N) | mg/L     |            | 5.47    | 0.765 |
| 10  | pH                  | -        |            | 1.65    | 7.58  |
| 11  | Hardness (CaCO\textsubscript{3}) | mg/L     |            | 2479.54 | 1050.18 |
| 12  | Zinc (Zn)           | mg/L     |            | 43.5    | 22.76 |
| 13  | Copper (Cu)         | mg/L     |            | 2.26    | 0.21  |
| 14  | Cadmium (Cd)        |          |            | < 0.004 | < 0.004 |
| 15  | Sulfate (SO\textsubscript{4}^{2-}) | mg/L     |            | 2780    | 720   |
| 16  | Lead (Pb)           | mg/L     |            | 2.92    | 5.01  |
| 17  | Sodium (Na)         | mg/L     |            | 1150.87 | 720.16 |
| 18  | Kalium (K)          | mg/L     |            | 325.71  | 215.48 |
In order to obtain analysis data, it is necessary to analyze the equipment calibration trace. Measurement traceability according to the International Vocabulary of Metrology (JCGM 200: 2012), is defined as the nature of the measurement results that can be connected to a particular reference, through a documented unbroken calibration chain, each of which contributes to measurement uncertainty. Measurement traceability activities can be considered correct if it can be proven that the measurement results are in accordance with the primary standard value. But in reality, it is not easy to directly measure primary standards. Besides because the primary standard is limited in number and may be stored in a place that is difficult to reach due to cost factors. So with consideration of cost and practicality, a standard measurement hierarchy system is created, where the primary standard position is at the top of the hierarchy.

In the concept of measurement traceability which is also known as metrological traceability, the correctness of measurement can be obtained by means of measuring activities using a measuring instrument. The measuring instrument must be calibrated with a calibration standard that has a higher accuracy, as well as the calibration standard in question which must also be calibrated with a higher one; so on until it goes to the primary standard and SI unit. It states that the existing measuring instrument can be ascertained its value in accordance with the measurement value of the primary standard [1]. So that traceability of this measurement has another purpose as a guarantee of the correctness of the value of the measuring instrument used.

4. Discussion

From this study, measurements were taken regarding the parameters that had been set. The measurement must go through a measurement hierarchy. In the concept of measurement traceability which is also known as metrological traceability, the correctness of measurement can be obtained by means of measuring activities using a measuring instrument. The measuring instrument must be calibrated with a calibration standard that has a higher accuracy, as well as the calibration standard in question which must also be calibrated with a higher one; so on until it goes to the primary standard and SI unit. It states that the existing measuring instrument can be ascertained its value in accordance with the measurement value of the primary standard. So that traceability of this measurement has another purpose as a guarantee of the correctness of the value of the measuring instrument used [11].

All measuring instruments used must be ensured that they are not interrupted by their traced chains. Moreover, the measuring instruments used are related to strategic matters, one of them is a measuring instrument that concerns the lives of many people. To guarantee the traceability of a measurement, the measuring instrument used must be calibrated. The calibration process is intended to determine and determine the correction that is owned by the measuring instrument is still within the limits of the performance of the allowed performance. This performance limit is known as tolerance or maximum permissible error (MPE). The calibration process is carried out by comparing directly to a measurement standard that already has a calibration certificate. Output released from calibration activities is in the form of a certificate and can also be a label or sticker given as a sign on a calibrated device [12].

If the process of guaranteeing traceability of measurement of a measuring instrument is problematic, then it can be ascertained that the size of the measurement that belongs to the standard is also problematic. Therefore, the task of ensuring traceability is very important, especially with regard to the primary quantity, both of which are owned by a calibration laboratory, let alone standards that are owned by national metrology institutions such as the LIPI Metrology Research Center.

5. Conclusion

All measuring instruments used must be ensured that they are not interrupted by their traced chains. Moreover, the measuring instruments used are related to strategic matters, one of them is a measuring instrument that concerns the lives of many people. To guarantee the traceability of a measurement, the measuring instrument used must be calibrated. The calibration process is intended to determine and determine the correction that is owned by the measuring instrument is still within the limits of the
performance of the allowed performance. This performance limit is known as tolerance or maximum permissible error (MPE). The calibration process is carried out by comparing directly to a measurement standard that already has a calibration certificate. Output released from calibration activities is in the form of a certificate and can also be a label or sticker given as a sign on a calibrated device.

**Conflict of Interest**
No conflict of interest

**Acknowledgement**
This research was supported in Prioritas Nasional LIPI 2018 has provided funding and support of research that has been done. Team at UPT BPI-LIPI and Mrs. Sudaryati has supported the sustainability of this research until it can be implemented in Bangka Barat.

**References**
[1] Langlais, B., Reckhow, D. A., Brink, D.R. 1991. *Ozone in Water Treatment: Application and Engineering*. Michigan. Lewis Publisher, Inc. 2 369-70
[2] Munter, Rein. 2001. *Advanced Oxidation Processes – Current Status and Prospects*. Department of Chemical Engineering: Tallinn Technical University. 2 215.
[3] Tchobanoglous, George, Burton, F.L., Stensel, H.D. 2003. *Wastewater Engineering, Treatment and Reuse*. 4th Edition. Metcalf & Eddy, Inc. Mc Graw Hill, New York. 4 275.
[4] Fakhurroja, Hanif. 2010. *Membuat Sumur Air di Berbagai Lahan*. Depok: Griya Kreasi. 1 15-20.
[5] T.H.Y. Tebbutt. 2001. *Principles of water quality control*. Department of civil engineering University of Brimingham. 2 60.
[6] Environmental Protection Agency Guidance Manual 3-42, 1999. 60.
[7] Hariyadi. Sugiono. Fakhurroja, H. Tanu, Edi. 2011. Analisis Hasil Uji Terap Alat Penghemat BBM Electric Fuel Treatment pada Engine Diesel Genset 35 KVA dengan Beban Statis. Jurnal Teknologi Indonesia, 34 68-76.
[8] Suradiputra, I Nyoman, Dibjo Sartono, dan Muhammad Ilman. 2005. *Krisis Air di Indonesia*. Prosiding Kongres Ilmu Pengetahuan Nasional VIII: Air untuk Pembangunan Berkelanjutan. Jakarta: LIPI Press. 20-25.
[9] Hariyadi. 2004. Metode dan Alat untuk Meningkatkan Kinerja Bahan Bakar Minyak. No Patent ID P 0022630 Indonesia. 1 September 2004. 4-8.
[10] Howard, P., Fiona R., Metrology in Short 3rd Ed. Euramet, UK, 2008. 10-15.
[11] Drijarkara, A.P, Ghufron Z., 2005. *Metrologi: Sebuah Pengantar, Pusat Penelitian Kalibrasi, Instrumentasi, dan Metrologi*. 5-10.
[12] Pusat Penelitian Kimia LIPI. 2012. *Laporan Hasil Analisis: No. 0052-B/LPPK/IV/2012*. 4-7.