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SPASIAL DISTRIBUTION OF GROUNDWATER QUALITY AND DESCRIPTION OF WATER-RELATED DISEASES IN BRINGKENG VILLAGE, KAWUNGANTEN DISTRICT, CILACAP REGENCY

DISTRIBUSI SPASIAL KUALITAS AIR TANAH DAN DESKRIPSI PENYAKIT YANG BERKAITAN DENGAN AIR DI DESA BRINGKENG, KECAMATAN KAWUNGANTEN, KABUPATEN CILACAP

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ABSTRACT

Access to clean water is fundamental for the population health, but for many rural and remote areas in Indonesia include Cilacap Regency those accesses are still limited. Furthermore, studies that assess the water quality in remote and rural areas in Indonesia are still lacking. Most of the people in Cilacap regency use dug wells and ponds as sources of clean water. Preliminary observations indicate that well and pond water smells fishy, reddish-yellow, or brownish. This condition indicates high iron levels. The test results showed that the iron content exceeded the standard in the pond in Sumbereja Hamlet, RT 03 RW 02, which was 9.8 mg/l (standard quality of 1 mg/l). This study aims to determine the spatial distribution of the water quality and the health-related problems in the rural areas of Cilacap Regency, Central Java, Indonesia. This was a descriptive observational study with a cross-sectional approach. We purposely sampled 40 wells and ponds located in Bringkeng Village, Cilacap Regency, Indonesia and assess the water quality by measuring the level. The results showed the lowest and the highest level of TDS (125.90-5090 mg/l), color (40 -2047 TCU), iron (0.16-6.45 mg/l), manganese (<0.1- 3.61 mg/l). Health problems experienced by respondents and or their families during the last three months, namely 3 people with diarrhea, 7 people with diabetes, 12 people with gout arthritis, 10 people with hypertension, 1 person with nervous system disorders, and 7 people with dry skin disorders/scaly. All dug wells and ponds did not meet the quality standards based on TDS, color, iron, and manganese levels. Water from dug wells and ponds needs special treatment to obtain water that is suitable for hygiene and sanitation purposes.

Keywords**:** *distribution, hygiene, mapping, sanitation, water quality*

ABSTRAK

Akses terhadap air bersih sangat penting bagi kesehatan penduduk, namun bagi banyak daerah pedesaan dan terpencil di Indonesia termasuk Kabupaten Cilacap akses tersebut masih terbatas. Selain itu, penelitian yang menilai kualitas air di daerah terpencil dan pedesaan di Indonesia masih kurang. Sebagian besar masyarakat di Kabupaten Cilacap menggunakan sumur gali dan kolam sebagai sumber air bersih. Studi pendahuluan menunjukkan bahwa air sumur dan kolam berbau amis, kuning kemerahan, atau kecoklatan. Kondisi ini menunjukkan kadar zat besi yang tinggi. Hasil pengujian menunjukkan kadar besi melebihi baku mutu pada kolam di Dusun Sumbereja RT 03 RW 02 yaitu 9,8 mg/l (baku mutu 1 mg/l). Penelitian ini bertujuan untuk mengetahui sebaran spasial kualitas air dan masalah kesehatan yang berkaitan dengan air di pedesaan Kabupaten Cilacap, Jawa Tengah, Indonesia. Penelitian ini merupakan penelitian observasional deskriptif dengan pendekatan cross sectional. Kami memilih 40 sumur dan kolam yang terletak di Desa Bringkeng, Kabupaten Cilacap dan menilai kualitas air dengan mengukur kadarnya. Hasil penelitian menunjukkan kadar TDS terendah dan tertinggi (125,90-5090 mg/l), warna (40 -2047 TCU), besi (0,16-6,45 mg/l), mangan (<0,1- 3,61 mg/l). Gangguan kesehatan yang dialami responden dan atau keluarganya selama tiga bulan terakhir yaitu diare 3 orang, diabetes 7 orang, artritis gout 12 orang, hipertensi 10 orang, gangguan sistem saraf 1 orang, dan kulit kering 7 orang kelainan/bersisik. Semua sumur gali dan kolam tidak memenuhi baku mutu berdasarkan kadar TDS, warna, besi, dan mangan. Air dari sumur gali dan kolam memerlukan perlakuan khusus untuk mendapatkan air yang layak untuk keperluan higiene dan sanitasi.

Kata kunci: distribusi, higiene, pemetaan, kualitas air, sanitasi

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INTRODUCTION

One of the goals in the Sustainable Development Goals is Clean Water and Sanitation (SDGs 6). This goal culminates in ensuring the availability and sustainable management of clean water and sanitation for all people by 2030. In 2018, Nationally, 73.68% of households accessed decent drinking water sources, and the provincial level in Central Java was 78.16% (Ministry of Health of the Republic of Indonesia, 2018). In 2017, the level of access to proper sanitation in the Cilacap Regency was 82.1% (Cilacap District Health Office, 2017).

This shows that access to sanitation, clean water, and drinking water needs to be improved so that the SDGs target can be achieved.

Another important aspect is the quality of water used by the community. Clean water quality standards or water for hygiene and sanitation are regulated through the Regulation of the Minister of Health of the Republic of Indonesia Number 32 the Year 2017, namely that water must meet physical, biological, and chemical requirements (Ministry of Health of the Republic of Indonesia, 2017). To maintain water quality, it is necessary to monitor water quality by testing water samples.

The people of Bringkeng Village who have not been served by PDAM use clean water from dug wells, ponds, and rainwater reservoirs to fulfill their daily needs such as bathing, washing, and cooking. The water from the dug wells and ponds used by the community is reddish and blackish which indicates the presence of iron and manganese.

The presence of excessive iron in water can cause various problems both technical problems and impacts on human health. The technical problem caused by iron is that it can change the color, taste, and odor of water leaving stains on clothes, creating scale, and iron deposits in pipes, which can block water from flowing or damage the hot water tank (Behera et.al, 2012 and Rizk et.al, 2017).

Excess iron in the body can increase the risk of diabetes mellitus, liver cancer, cirrhosis of the liver, heart diseases, and infertility (Simcox and McClain, 2013, Behera et.al, 2012). Excess manganese leads to neurological disorders known as manganism with symptoms that include tremors, difficulty walking, and facial muscle spasms (ATSDR, 2012). The purpose of this study was to determine the distribution of water quality based on TDS, color, iron, and manganese parameters and to describe the health-related problems in Bringkeng Village, Kawunganten District, Cilacap Regency.

METHODS

This was a descriptive observational study with a cross-sectional approach. We purposively sampled households in Bringkeng Village, Kawunganten District, Cilacap Regency who use dug well water or pond as a source of clean water, namely water used for domestic purposes. We sampled a total of 40 households and proportionally distributed them

into two hamlets which were Sumbereja (26) and Sidaurip (14). Each well or pond coordinate was measured using the Global Positioning System (GPS) and then described spatially using the ArcGIS program.

Total Dissolved Solids (TDS), color, iron (Fe), and manganese (Mn) were measured to indicate the water quality. TDS was measured using the potentiometric method while color was measured by the colorimetric method. The iron (Fe) level was measured using the phenanthroline method while the manganese (Mn) level was measured using the pressurized method.

Data Collection

Data collection was conducted in August 2020. Water samples were collected for laboratory examination using a 1-liter plastic jerrycan that had been cleaned. The principle of sampling by applying the minimization of aeration. The water samples were then examined at the Cilacap District Health Laboratory.

We interviewed respondents about health-related problems experienced by the respondents and their family members in the last three months using a questionnaire. The health-related problems included diarrhea, cholera, typhus, dysentery, nausea, vomiting, itchy skin, dry skin, scaly skin, nervous system disorders, hypertension, headaches, dizziness, poisoning, intestinal damage, hemochromatosis, cirrhosis, liver cancer, diabetes, heart failure, arthritis, impotence, infertility, hypothyroidism, and chronic fatigue.

Data Analysis

Water quality data including TDS, color, iron, and manganese were grouped in tabular form using Ms. Excel 2013. Water quality was analyzed by comparing water quality standards for sanitation and hygiene purposes based on the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of the Year 2017.

Research results displayed in the form of maps, tables, and graphs regarding the quality of clean water based on physical parameters (TDS and color), and chemical parameters (iron and manganese) in clean water sources in Bringkeng Village, Kawunganten District, Cilacap Regency. The mapping of the distribution of clean water quality is carried out using the Geographic Information System program.

Research Ethics

This research has been reviewed by and received ethical approval from the Health Research Ethics Committee (KEPK) of the Faculty of Medicine Universitas Jenderal Soedirman with Reference Number 154/ KEPK/VI/2020.

RESULTS AND DISCUSSION

I. Distribution of Water Quality of Wells and Ponds In Bringkeng Village

The results of measuring the quality of wells and pond water in Bringkeng Village are shown in Table 1 below.

Table 1. The average, standard deviation, minimum, and maximum level of groundwater quality

Parameter	Mean	Standard Deviation	Min-Max	Quality Standards	The percentage that meets the standard
Total Dissolved Solids	1160.86	1057.32	125.90 – 5090	1000 mg/L	65
Color	299.35	409.689	40 – 2047	50 TCU	2,5
Iron (Fe)	2.58	1.94	0.16 – 6.45	1 mg/L	25
Manganese (Mn)	1.02	0.83	< 0.1 – 3.61	0.5 mg/L	30

The results of water quality are compared with the Regulation of the Minister of Health of the Republic of Indonesia Number 32 the year 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Hygiene and Sanitation Needs, Swimming Pools, Solus per Aqua, and Public Baths.

a. Total Dissolved Solids (TDS)

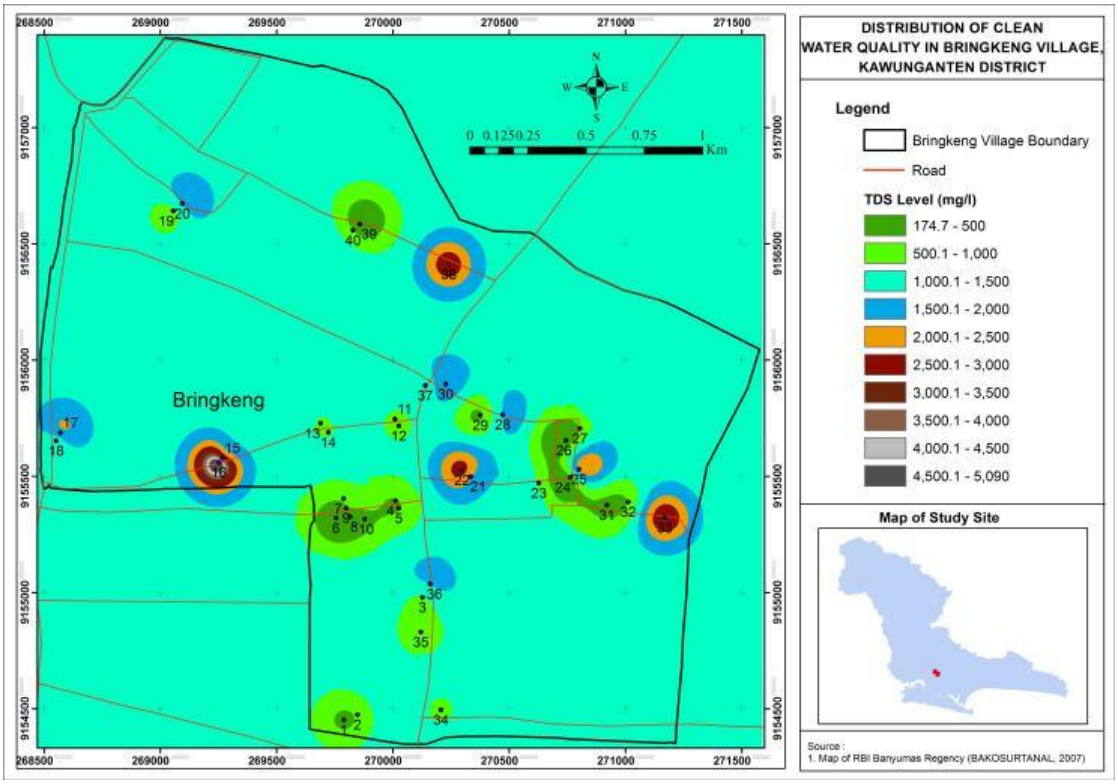

Figure 1. Map of the distribution of Total Dissolved Solids

The minimum level of TDS in wells and ponds in Bringkeng Village was 125.90 mg/L and the maximum level was 5090 mg/L with an average level was 1160.86 mg/L. The quality standard for Total Dissolved Solids (TDS) level in water for hygiene and sanitation purposes was 1000 mg/L. A total of 26 wells and ponds (65%) met the quality standard and 14 wells and ponds (35%) did not meet the quality standard based on TDS parameters. The spatial distribution of TDS is shown in Figure 1. Wells with TDS levels exceeding the quality standard gather at points 15,16,21, and 22.

Total dissolved solids are the anhydrous residues of the dissolved constituents present in water (Sherrard et.al, 1987). It consists of inorganic matter and small amounts of organic matter (Rahmanian, 2015). The main ingredients are usually the cations such as calcium, magnesium, and potassium and the anions such as carbonate bicarbonate, nitrate, chloride sulfate, etc (Islam et.al, 2016).

The lowest TDS level was at Point 26th located in Sidaurip Hamlet RT 2 RW 4, and the highest was at Point 16th located at Sumbereja Hamlet RT 2 RW 3. TDS is a water quality parameter related to aesthetic indicators. High TDS levels do not have an immediate negative effect on health, depending on the substance that causes the high TDS.

The high level of TDS is due to the large amount of organic and inorganic compounds which are dissolved in water, minerals, and salts. The TDS value of water is strongly influenced by rock weathering, runoff from the soil, and anthropogenic influences (in the form of domestic and industrial waste). The lowest TDS level at point 26th can be influenced by the location of the pond close to irrigation canals which causes dilution of the concentration of dissolved solids in the water. The results showed that the TDS level was high, so it was necessary to make specific measurements of the contaminants causing it.

b. Color

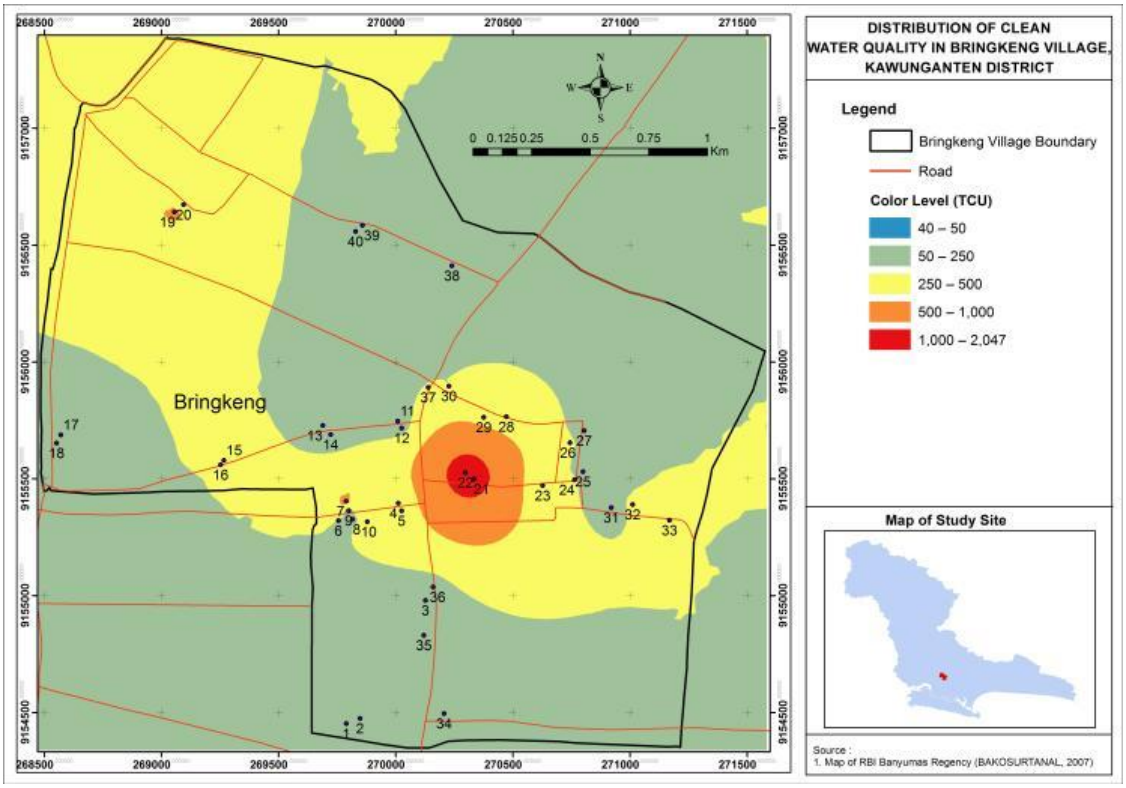

Figure 2. Map of the distribution of Color

The minimum level of wells and ponds color in Bringkeng Village was 40 TCU and the maximum level was 2047 TCU with an average level of 299.35 TCU. The quality standards for color in water for hygiene and sanitation purposes was 50 TCU. Only 1 well (2.5%) met the quality standards and a total of 39 wells and ponds (97.5%) did not meet the quality standard based on color parameters. The lowest color content is in well 34 with the physical condition of the protected (closed) well not having any anthropogenic pollutant sources around the well.

Organic matter such as plants and decaying inorganic matter (soil, stones, and rocks) give water its color. The presence of color is undesirable for more aesthetic than health reasons. Color is a measurement of aquatic humic substances, but is also influenced by other factors, for example, iron and nitrate concentration, differences in pH, and iron redox (Johansson et.al, 2010).

The lowest color level was at Point 34th located in Sidaurip Hamlet RT 3 RW 1, and the highest was at Point 22nd located at Sidaurip Hamlet RT 4 RW 4. The high color level is largely due to the high levels of iron and manganese in wells and ponds in Bringkeng Village. Besides, it can be caused by unprotected conditions of wells and ponds which make it easier for pollutants to enter wells and ponds. High levels of color can be caused by the presence of iron which causes the color of the water to turn red. At point, 22nd is the pool with the highest levels of color, iron, and manganese. The tendency for high levels of color is caused by high levels of iron.

c. Iron (Fe)

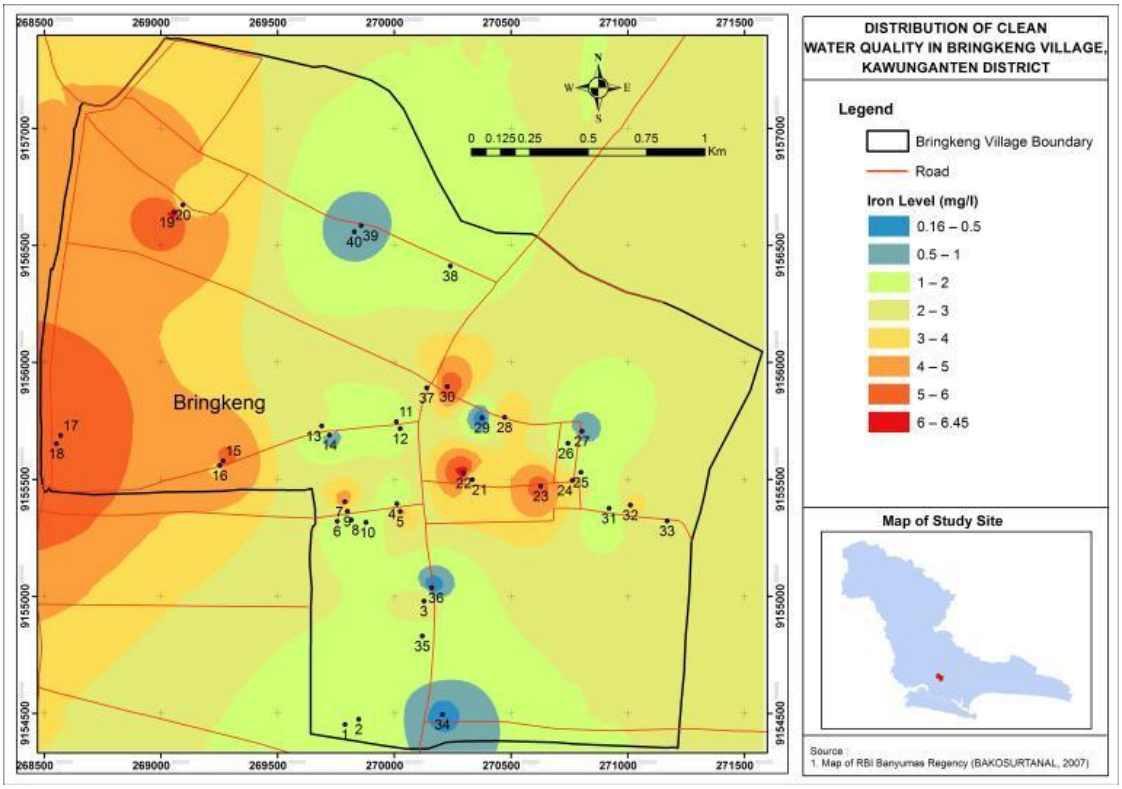

Figure 3. Map of the distribution of Iron (Fe)

The results showed the minimum level of iron (Fe) in wells and ponds in Bringkeng Village was 0.16 mg/l and the maximum level was 6.45 mg/l with an average level was 2.58 mg/l. The quality standard for iron (Fe) level in water for hygiene and sanitation purposes was 1 mg/l. A total of 30 wells and ponds (75%) did not meet the quality standards and 10 wells and ponds (25%) met the quality standards based on iron (Fe) parameters.

The presence of iron is one of the most frequent problems in groundwater. Iron may be insoluble (ferric hydroxide), soluble (ferrous bicarbonate), the iron atoms are also reduced from Fe^{3+} to Fe^{2+}. For Insoluble the water can appear rusty or yellowish in color. This happens because the iron is being oxidized by the atmosphere and forming ferric hydroxide. For Soluble iron in the water will appear clearly, but by time the iron will oxidize into particulate. Organic iron is combined with an acid, which can be clear, but usually has a yellowish-to-red color (Ibrahim, 2016).

The lowest level of Iron was at Point 34th located in Sumbereja Hamlet RT 2 RW 2, and the highest level was at Point 22nd located in Sidaurip Hamlet RT 4 RW 4. The high iron content is due to the fact that Bringkeng Village is an area with sedimentary soil characteristics. Most of the iron element is found in the soil which contains sedimentary rocks containing iron oxides, carbonates and sulfides (Sudadi, 2003).

d. Manganese

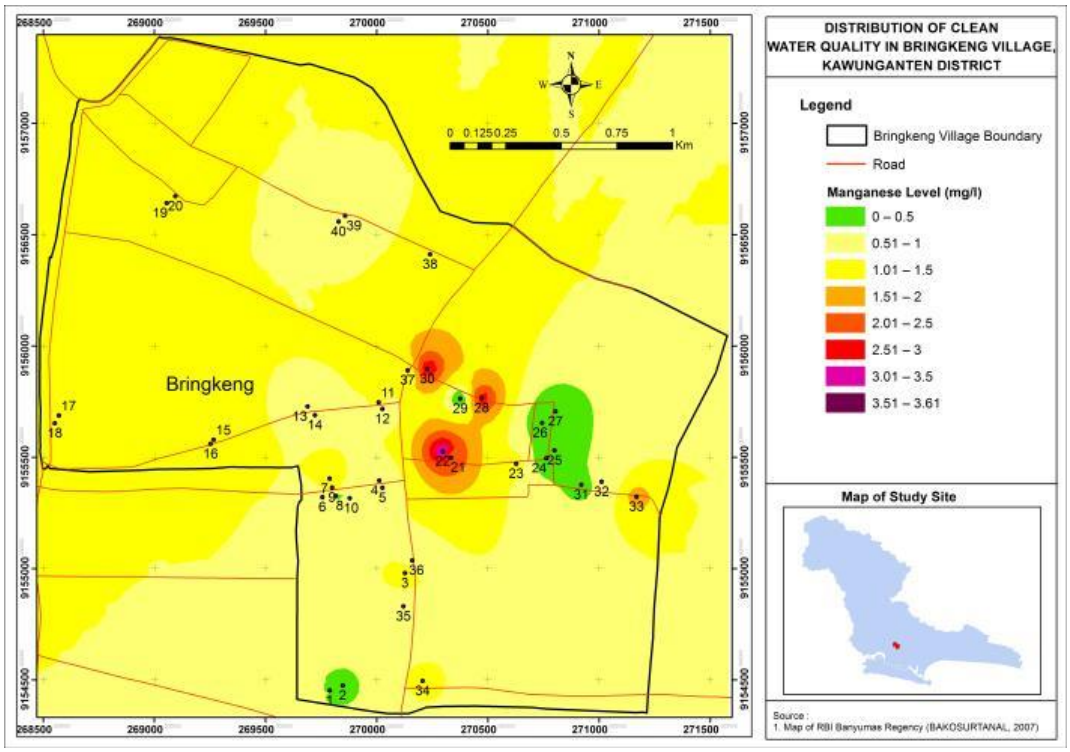

Figure 4. Map of the distribution of Manganese (Mn)

The results showed the minimum level of manganese in wells and ponds in Bringkeng Village was <0.1 mg/l and the maximum level was 3.61 mg/l with an average level was 1.02 mg/l. The quality standard for manganese (Mn) level in water for hygiene and sanitation purposes was 0.5 mg/l. A total of 28 wells and ponds (70%) did not meet the quality standards and 12 wells and ponds (30%) met the quality standards based on manganese (Mn) parameters.

Manganese is one of the most abundant metals on earth, comprising approximately 0.1%. It is usually found in rocks, soil, and water (Pinsino et.al, 2012). Manganese is an essential nutrient in humans and animals, that plays a role in bone mineralization, protein

and energy metabolism, metabolic regulation, cellular protection from damaging free radical species, and the formation of glycosaminoglycans (Wedler, 1994).

However, excessive manganese exposure either through dietary intake, inhalation, and dermal absorption can harm health. Chronic exposure to lower doses of manganese is associated with deficits in the ability to perform rapid hand movements and loss of coordination and balance, accompanied by symptoms of forgetfulness, anxiety, or insomnia. Chronic exposure to manganese at higher doses causes permanent neurological damage (ATDSR, 2012).

The lowest manganese level was at Point 25th, 27th, and 29th located in Sidaurip Hamlet RT 3 RW 4, Sidaurip RT 3 RW 4, and Sidaurip RT 1 RW 4 respectively, and the highest was at Point 22nd located at Sidaurip Hamlet RT 4 RW 4.

II. Water-Related Diseases in Bringkeng Village

Health problems due to water use experienced by respondents during the last three months are shown in Table 2 below.

Table 2. Health problems experienced by respondents and or their families

No.	Health Problem	Frequency
1.	Diarrhea	3 people
2.	Diabetes	7 people
3.	Gout Arthritis	12 people
4.	Hypertension	10 people
5.	Nervous system disorders	1 person
6.	Dry skin/scaly	7 people

Health problems experienced by respondents and or their family members who use wells and ponds water for hygiene and sanitation purposes were carried out by interview using a questionnaire. Water quality in all wells and ponds in Bringkeng Village did not meet quality standards based on TDS, color, iron, and manganese measurements. Pollutants contained in water can enter the human body through the skin, be ingested through eating utensils, or food washed using water from dug wells and ponds.

This article describes the health problems experienced by respondents or their families in the last three months. This paper did not link water quality to public health interference. However, we did mention some literature that showed the relationship

between the two. A total of 3 people experienced diarrhea.Literature suggests that 10-20 mg/kg of ingested elemental iron can cause mild toxicity resulting in gastrointestinal symptoms such as abdominal pain, nausea, vomiting, and diarrhea.

Based on the results of interviews with respondents, it was found that three people had diarrhea. Literature suggests that 10-20 mg/kg of ingested elemental iron can cause mild toxicity resulting in gastrointestinal symptoms such as abdominal pain, nausea, vomiting, and diarrhea (Geraci and Heagney, 2012). As many as 7 people had diabetes. Excess iron is a risk factor for diabetes. Iron plays a direct and causal role in diabetes pathogenesis mediated both by β-cell failure and insulin resistance (Simcox and McClain, 2013). As many as 12 people had gout arthritis. Genetically high iron status was positively associated with gout and inversely associated with rheumatoid arthritis (Yuan and Larsson, 2020).

One person had nervous system disorders. Manganese plays a role in manganism and Parkinson's Disease. Manganese has also been implicated in other neurological diseases such as Huntington's disease and prions (Harischandra et.al, 2019). As many as 10 people had hypertension. Several studies have identified an association between excess salinity in drinking water and an increased risk of hypertension. Water salinity proxies are Total Dissolved Solids (TDS) and electrical conductivity (Chakraborty, 2019).

As many as 7 people had dry skin/scaly. Interaction between metals and cell membranes play a key role in metals-induced toxicity by inducing Reactive Oxygen Species (ROS) production. This ROS production can damage proteins, DNA of the cells but also can trigger inflammation through activation of cytokines and might be involved in the initiation or pathogenesis of allergic or nonallergic cutaneous inflammation.

CONCLUSION

The results of water quality based on TDS levels, color, iron, manganese, it can be concluded that all well water and ponds in Bringkeng Village, Kawunganten District Cilacap Regency do not meet health requirements. The community is expected to carry out adequate water treatment before using the water.

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REFERENCES

ATSDR (Agency of Toxic Substances and Disease Registry). 2012. Toxicological profile for manganese, U.S. Department of Health and Human Services Public Health Service.

Behera, B.. Das, M. and Rana, G.S. 2012. Studies on ground water pollution due to iron content and water quality in and around, Jagdalpur, Bastar District, Chattisgarh, India. J. Chem. Pharm. Res. 4 (8): 3803-3807.

Chakraborty, R., Khan, K. M., Dibaba, D. T., Khan, M. A., Ahmed, A., & Islam, M. Z. 2019. Health implications of drinking water salinity in coastal areas of Bangladesh. *International Journal of Environmental Research and Public Health* 16 (19), 1–10. https://doi.org/10.3390/ijerph16193746

Dinas Kesehatan Kabupaten Cilacap. 2017. Profil Kesehatan Kabupaten Cilacap Tahun 2017.

Geraci, M. J., & Heagney, H. 2012. Iron Overdose during Pregnancy: Case and Treatment Review. *International Journal of Clinical Medicine* 03 (07), 715–721. https://doi.org/10.4236/ijcm.2012.37a126

Harischandra, D. S., Ghaisas, S., Zenitsky, G., Jin, H., Kanthasamy, A., Anantharam, V., & Kanthasamy, A. G. 2019. Manganese-induced neurotoxicity: New insights into the triad of protein misfolding, mitochondrial impairment, and neuroinflammation. *Frontiers in Neuroscience* 13(JUN), 1–19. https://doi.org/10.3389/fnins.2019.00654

Islam, R. et.al. 2016. M. A Study on the TDS Level of Drinking Mineral Water in Bangladesh. *American Journal of Applied Chemistry*.; 4(5), 164. https://doi.org/10.11648/j.ajac.20160405.11

Ibrahim, N.I.M. The Relations Between Concentration of Iron and the pH Ground Water (Case Study Zulfi Ground Water). 2016. *International Journal of Environmental Monitoring and Analysis* 4(6), 140. https://doi.org/10.11648/j.ijema.20160406.11

Johansson, L., Temnerud, J., Abrahamsson, J., & Kleja, D. B. 2010. Variation in organic matter and water color in Lake Mlaren during the past 70 years. *Ambio*. 39 (2), 116–125. https://doi.org/10.1007/s13280-010-0019-2

Kementerian Kesehatan Republik Indonesia. 2017. Peraturan Menteri Kesehatan Republik Indonesia Nomor 32 Tahun 2017 tentang Standar Baku Mutu Kesehatan Lingkungan dan Persyaratan Kesehatan Air untuk Keperluan Higiene Sanitasi, Kolam Renang, *Solus Per Aqua*, dan Pemandian Umum. Jakarta.

Kementerian Kesehatan Republik Indonesia. 2018. Data dan informasi profil kesehatan indonesia. Jakarta. 2018.

Pinsino, A., Matranga, V., & Carmela, M. 2012. Manganese: A New Emerging Contaminant in the Environment. *Environmental Contamination* 16–36. https://doi.org/10.5772/31438

Rahmanian, N., Ali, S. H. B., Homayoonfard, M., Ali, N. J., Rehan, M., Sadef, Y., & Nizami, A. S. 2015. Analysis of physiochemical parameters to evaluate the drinking water quality in the state of perak, Malaysia. *Journal of Chemistry*. https://doi.org/10.1155/2015/716125

Rizk, Zeinelabidin & Elsharaa, Intisar & El-Turki, Khadija. 2017. Iron determination of drinking water wells in Benghazi City. Earth-Science Reviews 3:47-53.

Sherrard, J. H., Moore, D. R., & Dillaha, T. A. 1987. Total dissolved solids: Determination, sources, effects, and removal. *Journal of Environmental Education*. 18 (2), 19–24. https://doi.org/10.1080/00958964.1987.9943484

Simcox, J.A. and D.A. McClain. 2013. Iron and Diabetes Risk. Cell Metab 17 (3): 329-341.

Sudadi, P. 2003. Penentuan Kualitas Air Tanah Melalui Analisis Kimia Terpilih. Sub Direktorat Pendayagunaan Air Tanah, DTLGKP. Bandung.

Wedler FC. 1994. Biochemical and nutritional role of manganese: An overview. In: Klimis-Tavantzis DJ, ed. Manganese in health and disease. Boca Raton, LA: CRC Press 1-36.

Yuan, S., and Larsson, S. 2020. Causal associations of iron status with gout and rheumatoid arthritis, but not with inflammatory bowel disease, Clinical Nutrition, https://doi.org/10.1016/j.clnu.2020.01.019