Analysis of groundwater quality in Cimahi City of West Java Province

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Abstract. Cimahi City is currently experiencing a clean water crisis, the cause of which is increasing population growth, so that water needs increase and land conversion, which results in reduced groundwater infiltration. The primary source of clean water in this city is groundwater. Population growth and residential development have an impact on pollution originating from domestic waste. These two things cause the quality and quantity of groundwater in Cimahi City to be increasingly critical. This study aims to analyze the quality of groundwater used by residents of Cimahi City. The data used is secondary data from the Environmental Service in 2019. Sampling was carried out at thirty points in Cimahi City spread over 14 urban villages, namely Citereup, Pasir Kaliki, Cibereum, Cibabat, Cipageran, Cimahi, Leuwigajah, Setiamanah, Karang Mekar, Cibeber, Melong, Cigugur, Padasuka, and Utama. The number of sampling is 1-2 samples/urban village. Based on the results of the analysis of parameters that do not exceed the required quality standards based on the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning the requirements and supervision of pristine water quality, namely: turbidity, Manganese, nitrate, detergent as MBAS, and total coliform. Based on the results of calculations with the water quality index, it is stated that the quality of groundwater in Cimahi City is in the normal-poor category.

1. Introduction

Cimahi City is a buffer zone for the capital city of West Java Province, namely Bandung City. The city is experiencing rapid population growth, which impacts increasing the need for land for settlements, the generation of domestic wastewater, garbage and others. The increase in population also causes the need for clean water to continue to grow. The primary source of clean water in Cimahi City is groundwater because local water companies have not served clean water for all residents in this city. It causes the exploitation of groundwater to increase, which impacts the occurrence of a decrease in groundwater reserves so that it reaches a critical level. A total of 1,174 households meet clean water needs using water from regional drinking water companies, with the highest user being Cimahi Tengah District. A total of 1,104 households in Cimahi City use other sources as their source of clean water. Residents of Cimahi City who use healthy water as a water source in South Cimahi District as many as 7,289 families, Central Cimahi Village as many as 970 families, and North Cimahi District as many as 927 families. In Cimahi City, 340 households use rainwater as a water source [1].

The generation of domestic wastewater resulting from daily human activities is one of the environmental problems in this area. Based on the characteristics of domestic wastewater, it is

categorized into greywater such as water used for washing in the kitchen, laundry, bathing and blackwater in the form of human waste. Domestic wastewater that is not managed correctly is a source of groundwater pollution [2]. This pollution is influenced by hydrogeological conditions, soil type, groundwater table depth, and the distance of the well from the local sanitation location [2]. The possibility of poor quality of healthy water can also be caused by sanitation that does not meet household standards, namely the absence of individual septic tanks or septic tanks that do not comply with regulations, thereby contaminating soil and groundwater [2].

This study aims to analyze groundwater quality in Cimahi City by calculating water quality and mapping the distribution of groundwater quality parameters that do not meet quality standards. The benefits of this research can provide an overview of groundwater pollution to assist local governments in making decisions to tackle groundwater pollution. This study uses quality standards based on the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning the requirements and supervision of clean water quality. Calculation of water quality using the water quality index (WQI) [3]. The WQI method has been widely used to analyze groundwater quality in several countries such as Iraq, India, and Palestine [3],[4],[5]).

2. Methodology

This study uses secondary data on the quality of resident well water from the Environmental Service of Cimahi City in 2021. The number of samples is 30 scattered in 14 villages, namely Citereup, Pasir Kaliki, Cibereum, Cibabat, Cipageran, Cimahi, Leuwigajah, Setiamanah, Karang Mekar, Cibeber, Melong, Cigugur, Padasuka, and Utama. The analyzed parameters consisted of 5 physical parameters: TDS, turbidity, colour, odour, and temperature. Eleven chemical parameters, namely: pH, iron (Fe), Fluoride (F), hardness, Manganese (Mn), Nitrate as N, Nitrite as N, Sulfate, Zinc (Zn), detergent as MBAS, and Organic Substances ($KMnO_4$) and one microbiological parameter, namely total coliform. The quality standard used refers to the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning the requirements and supervision of clean water quality are contained in Appendix I. Table 1 presents the locations of sampling points, and Figure 2 shows the distribution of sampling points.

Table 1. Location of groundwater quality sampling points in Cimahi city.

Coordinate 1 - 5	Village	Citeureup	Pasir Kaliki	Cibeureum	Cibabat	Cipageran
	East	107º32’53”	107º33’14”	107º33’42”	107º33’21”	107º32’14”
	South	06º51’34”	06º53’15”	06º54’40”	06º52’48”	06º51’17”
Coordinate 6 - 10	Village	Cipageran	Cibabat	Cimahi	Leuwigajah	Cibeureum
	East	107º32’27”	107º33’14”	107º32’27”	107º31’31”	107º33’52”
	South	06º51’16”	06º53’41”	06º52’13”	06º33’55”	06º42’21”
Coordinate 11 - 15	Village	Setiamanah	Citereup	Pasir Kaliki	Leuwigajah	Baros
	East	107º32’10”	107º32’57”	107º33’42”	107º31’31”	107º32’31”
	South	06º52’31”	06º51’50”	06º53’18”	06º33’55”	06º53’26”
Coordinate 16 - 20	Village	Karang Mekar	Cibeber	Karang Mekar	Cimahi	Melong
	East	107º32’33”	107º31’076”	107º32’37”	107º32’26”	107º33’30”
	South	06º52’37”	06º53’349”	06º52’32”	06º52’19”	06º55’17”
Coordinate 21 - 25	Village	Cigugur Tengah	Padasuka	Cigugur	Melong	Setiamanah
	East	107º33’16”	107º31’51”	107º33’16”	107º33’48”	107º32’12”
	South	06º53’20”	06º52’35”	06º53’33”	06º54’56”	06º52’26”
Coordinate 26- 30	Village	Baros	Utama	Cibeber	Utama	Padasuka
	East	107º32’20”	107º32’228”	107º31’150”	107º32’161”	107º31’38”
	South	06º53’24”	06º54’484”	06º53’351”	06º54’455”	06º52’41”

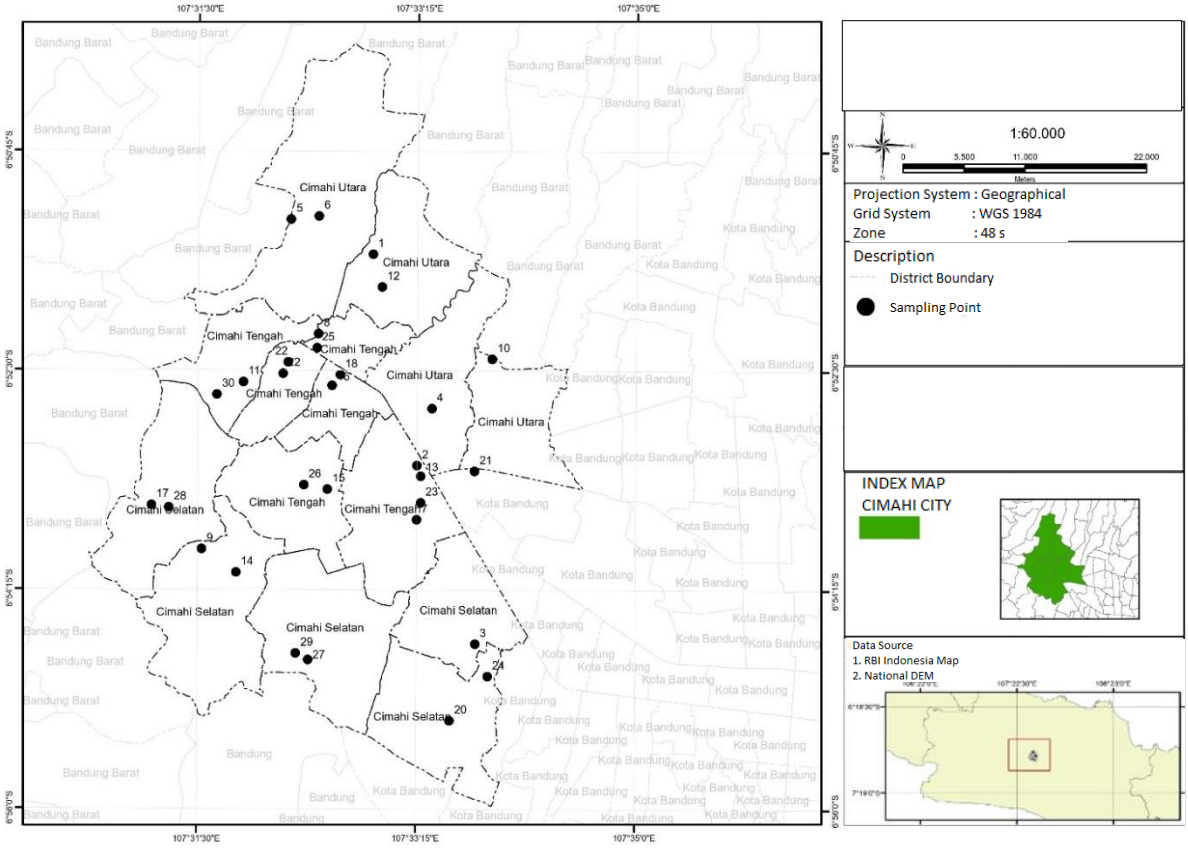

Figure 1. Location of Cimahi City groundwater quality sampling point.

WQI is a number that describes water quality by collecting the results of measuring water quality parameters [4],[5]. WQI is used to determine the level of water pollution based on nutrient parameters. The determination of the level of pollution based on WQI uses equation 1.

$$WQI = \frac{\sum_{i=1}^{n} C_1 P_1}{P_i} \quad (1)$$

Where: WQI = Water Quality Index, Ci = concentration of water quality parameters (i) the normalization results, Pi = the relative weighting of each parameter (i), and n = number of parameters. The determination of WQI is carried out by normalizing the data by transforming the value of the measurement results from n water quality parameters that have different units into values without units on a scale of 0-100. The weighting of water quality parameters is carried out to describe the importance of each parameter as an indicator of water quality. The weight of each parameter is given a value of 1 to 4 according to its level of importance for aquatic organisms. A value of 4 is given to the parameter that is considered the most important for aquatic organisms, and a value of 1 is given to the parameter that has the most negligible impact on the organism's life [6]. The resulting WQI values are classified into five classes, as presented in Table 2 [6].

Table 2. Criteria for waters based on the water quality index.

WQI Value	Water Quality
91-100	Excellent
71-90	Good
51-70	Medium
26-50	Bad
0-25	Very Bad

.3. Result and discussion

Based on the analysis results of 30 samples examined for groundwater quality, only 6 locations met the quality standards and were declared worthy of being a source of clean water. The rest there were 1 to 3 parameters that did not meet the quality standards. Locations that meet the quality standards are at sampling points 2, 9, 15, 20, 21, and 28. There are six sampling points where the Nitrate and Total Coliform parameters do not meet the quality standards, namely 1, 4, 11, 16, 21, and 26. 11 sampling points where the Total Coliform parameter does not meet the quality standard, namely 6, 7, 8, 13, 14, 19, 23, 24, 28, 29, 30. There are two sampling points where the Manganese and Total Coliform parameters do not meet the quality standard. Namely 2 and 22. The rest are sampling points of 3 parameters that do not meet the quality standards, namely Turbidity, Nitrate and Total Coliform. Sampling points of 5 parameters that do not meet the quality standards, namely manganese and detergent as MBAS. Sampling points of 10 parameters that do not meet the quality standards, namely turbidity, the sampling point is 17 parameters that do not meet the quality standards, namely Turbidity and Manganese, the sampling point is 18 parameters that do not meet the quality standards, namely pH and Total Coliform. The sampling point is 27 parameters that do not meet the quality standards, namely Turbidity and Manganese.

Based on the analysis of 21 sampling points, or 70% of the groundwater has been contaminated with E Coli, this is due to groundwater contamination by domestic waste originating from septic tanks. Until now, in Cimahi City, the domestic wastewater management system is still not good [1]. Based on the research results in Cimahi City, there are five rivers polluted by domestic waste, the parameters that do not meet the quality standards are the same as in groundwater [7],[8]. The study concluded that the water quality of the five rivers in this city is categorized as heavily polluted, and there is a high possibility of contamination from rivers to groundwater [7],[8]. It carries water and causing groundwater to be unfit for human consumption. Figure 2 presents a profile of the concentration of pH, turbidity, manganese, nitrate, and detergent as MBAS and the total amount of Coliform in Cimahi City groundwater.

Turbidity of water is caused by suspended solids, both inorganic and organic. The groundwater quality measurements in Cimahi City, sampling location point 3, 70.9 NTU, sampling point 10 is 49.4 NTU, and sampling location 17 is 34.8 NTU. It can be due to the presence of inorganic substances that usually come from weathered plants and animals. Industrial effluents can also be a source of turbidity. When compared with the parameter of the quality standard of the Minister of Health of the Republic of Indonesia, Number 32 of 2017 is 25 NTU. Of the three groundwater samples tested, all three exceed the applicable quality standards.

Based on the quality measurement results, there are 3 points where the Manganese concentration has exceeded the quality standard, namely the sampling location at point 5, the result is 5 mg/L, sampling point 12 is 0.593 mg/L, and at the sampling location point 17, the result is 0.745 mg/L. The high Manganese content in groundwater is predicted because of the decay of rocks containing Manganese [9]. The high content of this element in groundwater can reduce the aesthetics of the water because this element can settle in clothes, bathroom walls and other solid markers.

Groundwater whose nitrate parameter does not meet the quality standard is located at the sampling location point 1 the result is 14 mg/L, the sampling location point 3 is 16.2 mg/L, the sampling location point 4 is 12.6 mg/L, the point sampling location is 11 the result is 11.3 mg/L. Moreover, the location of sampling point 16 the result is 17.7 mg/L. The high level of nitrate in groundwater is caused by the amount of household waste input influenced by the density of residential houses; the age of a settlement. Where the older the age of a settlement, the greater the nitrate in the area. A high concentration of nitrate in groundwater is hazardous for human health who consume it.

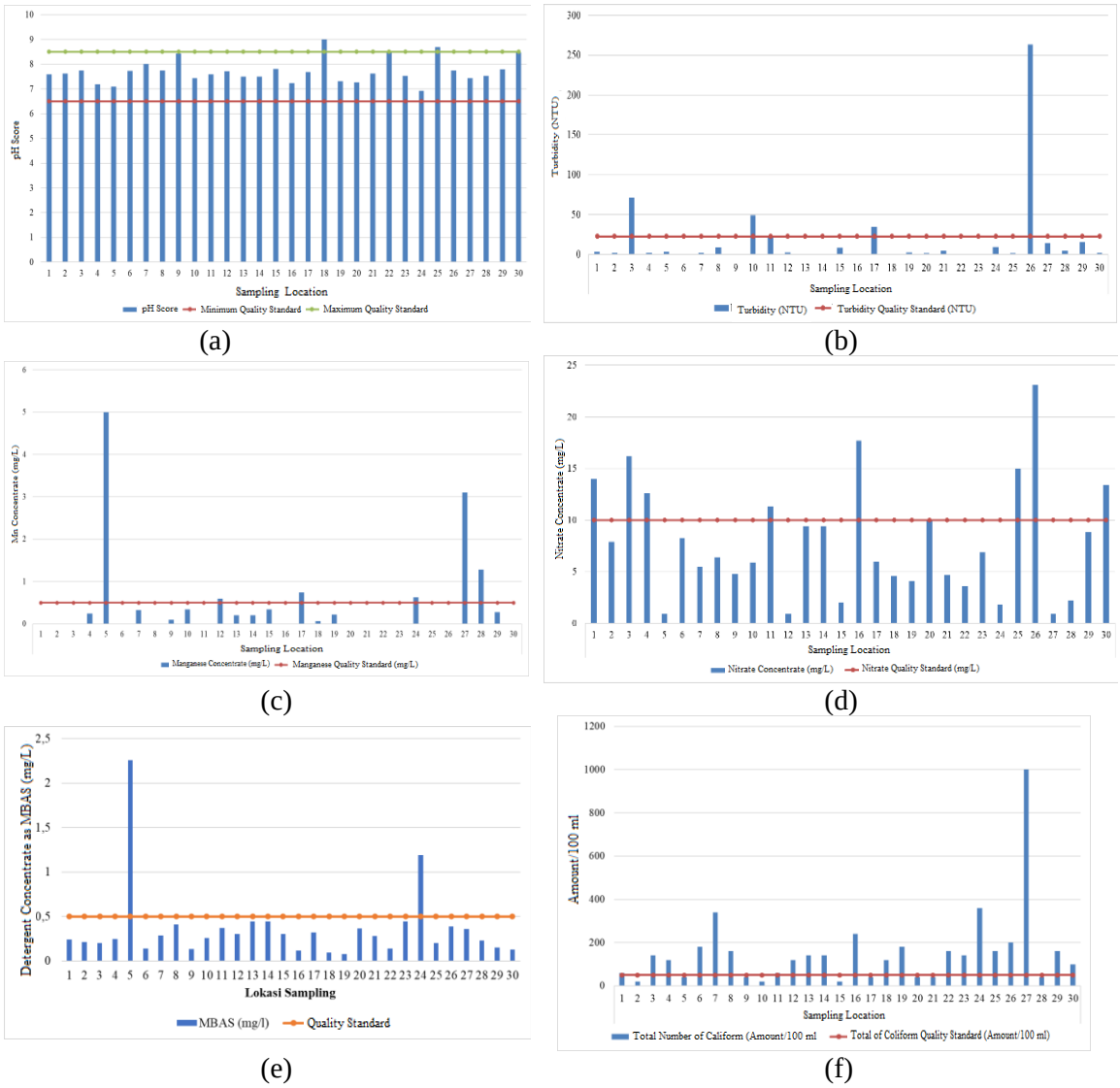

Figure 2. pH parameter profile (a), turbidity parameter profile (b), manganese parameter profile (c), Nitrate parameter profile (d), detergent as MBAS profile (e), total coliform parameter profile (f).

Based on Figure 2, there are 2 points where the detergent concentration as MBAS does not meet the quality standards, namely at sampling points 5 and 24. Detergent as MBAS found in groundwater is predicted to come from domestic wastewater contamination caused by leakage of septic tanks or due to poor construction. Not good enough to cause seepage. Steps to make understanding the position of polluted groundwater mapping is carried out as shown in Figure 3. Based on the figure, the red dots indicate parameters that do not meet the quality standards, while the black ones meet the quality standards. This mapping facilitates decision making to determine priority areas for handling groundwater pollution so that the efforts made are right on target.

Groundwater quality in Cimahi City is calculated using WQI. This method has been widely used in several locations and can provide an overview of groundwater pollution that occurs. Table 2 describes the results of the WQI calculations. Based on this method, it can be concluded that the groundwater quality in Cimahi City is categorized as usual to bad. Groundwater quality categorized as poor is found in three points, namely 3 in Cibeureum Village, 16 in Karang Mekar Village, and 26 in Baros Village.

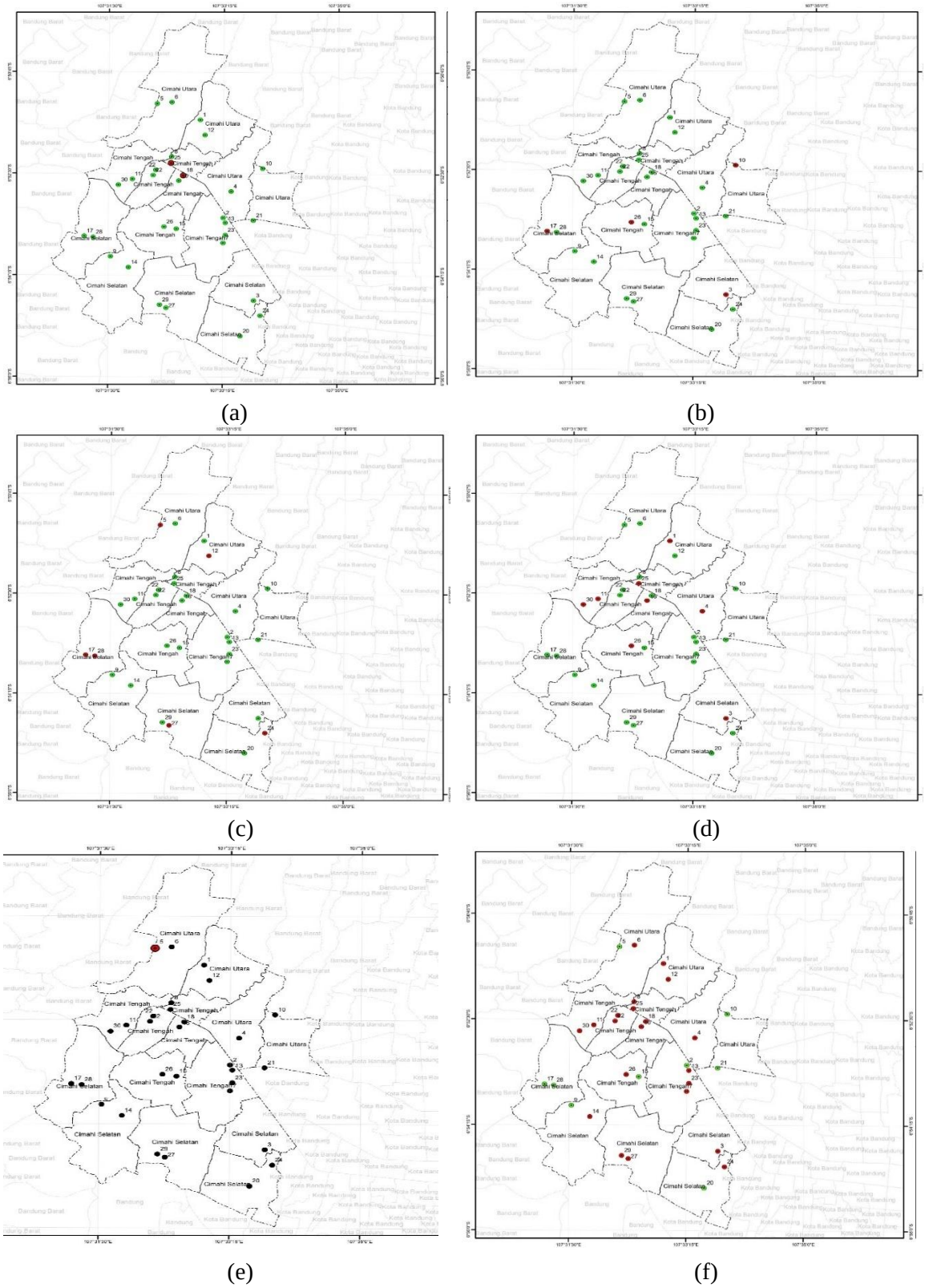

Figure 3. Distribution Map of pH parameter (a), turbidity parameter (b), manganese parameter (c), nitrate parameter (d), detergent as MBAS parameter (e), total Coliform parameter (f).

Based on Table 3, the WQI score ranges from 39-68. The lowest score is at point 26, and the highest score is at point 15. Based on the results of the WQI calculation, the sanitation system that must be immediately repaired is Cibeureum, Karang Mekar, and Baros Villages. Countermeasures are carried out by planning an excellent domestic wastewater management system using an offsite or on-site system that meets the applicable criteria. The selection of an appropriate domestic wastewater treatment system must refer to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia No. 04/PRT/M/2017 concerning the Implementation of a Domestic Wastewater Management System.

Table 3. Groundwater quality index in Cimahi City.

No Sample	Quality Index						WQI Score	Water Quality
	Temperature	pH	Turbidity	TDS	Nitrate	Total Coliform		
1	17	88	90	60	45	60	58	Medium
2	16	88	93	80	58	63	65	Medium
3	16	88	29	47	42	41	45	Bad
4	16	88	93	73	48	42	57	Medium
5	14	88	90	52	97	55	65	Medium
6	16	88	99	49	56	38	55	Medium
7	16	84	93	55	65	32	54	Medium
8	14	88	78	68	60	40	56	Medium
9	16	84	99	58	70	55	62	Medium
10	16	88	40	58	65	63	57	Medium
11	16	88	59	42	49	50	51	Medium
12	16	88	93	50	97	42	62	Medium
13	17	88	99	54	53	41	56	Medium
14	17	88	99	54	53	41	56	Medium
15	17	88	80	66	95	20	68	Medium
16	16	88	96	32	40	36	50	Bad
17	17	88	50	55	60	55	55	Medium
18	16	49	96	60	70	42	53	Medium
19	16	88	93	60	70	38	58	Medium
20	16	88	96	45	53	55	58	Medium
21	17	88	86	75	70	55	63	Medium
22	12	84	96	47	90	40	59	Medium
23	17	88	96	71	60	41	59	Medium
24	14	55	78	51	96	32	52	Medium
25	17	84	96	57	43	40	54	Medium
26	16	88	5	49	34	37	39	Bad
27	16	88	69	62	97	22	55	Medium
28	16	88	88	58	95	55	66	Medium
29	16	88	67	51	56	40	52	Medium
30	16	84	93	61	46	44	55	Medium

4. Conclusion

Based on the study results, it was concluded that the groundwater quality of Cimahi City was polluted by domestic waste. It is based on the measurement results of Total Coli, Detergent as MBAS, turbidity and Nitrate parameters that do not meet quality standards at several sampling points. Based on the results of the WQI calculation, the water quality in this city belongs to the standard category at 26 points and 4 locations, including the wrong category. Locations that fall into the bad category are Cibeureum, Karang Mekar, and Baros, thirsty for immediate efforts to control groundwater pollution.

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