Effect of Land Use on Ground Water Quality (A Case Study from Ciracas Sub District, East Jakarta, Indonesia)

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***Abstract*—Most of Ciracas society as a rural area had given a complain of worst groundwater that occured metally odour dan yellowish colour. To know the quality of groundwater of that it was conducted the research indicated by the existing of feacal Coliform and concentration of Fe and Mn. There were 5 villages as sites of sampling (Ciracas, Susukan, Kampung Rambutan, Kelapa Dua Wetan, and Cibubur Bekasi) where each locations was differed from the use to rice field, swamp, and garden. Microbial and chemical data were collected at each sites from 15 wells with three replications. Data were analyzed by One Way *Anova* to compare each locations with different land uses and concentration of Fe and Mn, and microbial data. *Pearson's* Correlation method was also used to analyze correlation between septic tank distance and concentration of *Coliform* and *E. coli*. The results showed that most of the groundwater surrounding Ciracas sub-district had been contaminted by *Coliform* and *Escherichia coli* ranging from 0 to 26.000 MPN/100 ml and 0 to 6790 MPN/100 ml, excluded Susukan village which was used to rice field, and this was significantly different at study sites in each land uses (p<0.05). Nevertheless, well depth and distance of septic tank to well were not significantly correlated with concentration of *Coliform* and *E. coli* (p>0.05). Swamp sites indicated high amount of Fe, more than 0,3 ppm and for the used to rice field showed less amount of Mn (< 0,1 ppm). Nevertheless, based on statistical results showed that there was no significant differences in concentration of Fe and Mn in different land uses at study sites (p>0.05) and also no correlation with well depth significantly ((p>0.05). Refer to DHMI No. 907/2002 about drinking water standard, it could be said that most of groundwater in Ciracas sub-district was not able to be used as drinking water. It is needed pre-treatment to drinkable.**

***Index Terms*—Bioindicator, coliform, escherichia *coli*, iron and manganese, well water,**

I. Introduction

Generally, the source of drinking water in Indonesia comes from surface water, groundwater and rain water, and groundwater is the mayor drinking water source [1]. Different sources of drinking water will cause different composition of water [2]. Globally, the quantity of water resource on earth is relatively constant while the quality has declined due to pollution.

The likelihood of groundwater contamination by the sewage disposal system systems is greatest where septic systems are closely spaced as in subdivided tracts in suburban areas and in areas where the bedrock is covered by little or no soil. Fecal bacteria, including *Coliform* and *Escherischia coli*, are mostly contaminated groundwater and further these are used as a biomonitoring tool for drinking water quality [3]. Fecal coliform bacteria are present in the gastrointestinal tract of humans and other warm-blooded animals. The presence of these bacteria in natural water indicates degradation by human or animal waste and may be related to septic tank waste.

Monitoring conducted by National Environmental Management Institution [4] in 75 wells in 2004-2005 was reported that groundwater surrounding Jakarta had high organic and inorganic pollutants. As a result, groundwater in Jakarta had no longer appropriate with water quality standard, especially for drinking water. At East Jakarta district, 45% of groundwater had been contaminated by fecal *Coliform* and 80% of *E. coli*. The same condition was also found at South Jakarta district that *E. coli* bacteria from septic tank effluent had contaminated most of ground water in range from 3-160 MPN/100 ml [5]. This was due to the dense of population which causes the location of wells was much closer to the septic tank systems [5]–[7].

In Ciracas sub-district, most of houses are adjacent to one another where the septic systems are certainly near the neighbor's wells. Moreover, the former land use in Ciracas sub-district were mostly swamp, rice field, and garden where were assumed causing in pollution problem in ground water by inorganic compounds. The Residents surrounding Ciracas sub-district are still using groundwater as drinking water source until now. Lately, there have been many complains from the residents due to bad quality of groundwater which was yellowish and smelling like iron. Therefore, it is necessary to analyze the ground water quality related to the former land uses and septic system.

II. Materials and Method

This study was conducted at 5 villages in Ciracas sub-district, East Jakarta district, Indonesia in of Ciracas sub-district, that were Susukan, Kampung Rambutan, Kelapa Dua Wetan, and Cibubur villages (Figure 1) and each villages was divided into 3 types of former land use (swamp, rice field, and garden). Ground water samples collected in 2009 from domestic wells were analyzed for concentration of iron and manganese, and also fecal bacteria, that were *Coliform* and *E. coli*, with 3 replications.

Measurement of physical parameters (pH and temperature) were conducted in situ, whereas for concentration of Fe and Mn and microbiological test were

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conducted in laboratory using the standard method. Concentration of iron and manganese were analyzed using AAS (*atomic absorption spectrophotometry*) to measure the absorbance. Total *Coliform* and *E. coli* bacteria were measured using the MPN (*Most Probably Number*) method which was conducted on 3 stages of analysis, that were determination of MPN presumptive *Coliform*/100 ml of water, determination of MPN faecal *Coliform*/100 ml of water and determination of MPN *E. coli*/100 ml of water. The media used to analyze the fecal bacteria was lactose broth with 4 dilutions of water samples: 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, then all samples in Durham tubes were incubated 37^{0}C for 24 hours for *E. coli* analysis and 48 hours for *Coliform* analysis. Determination of MPN is determined by matching the results with the table.

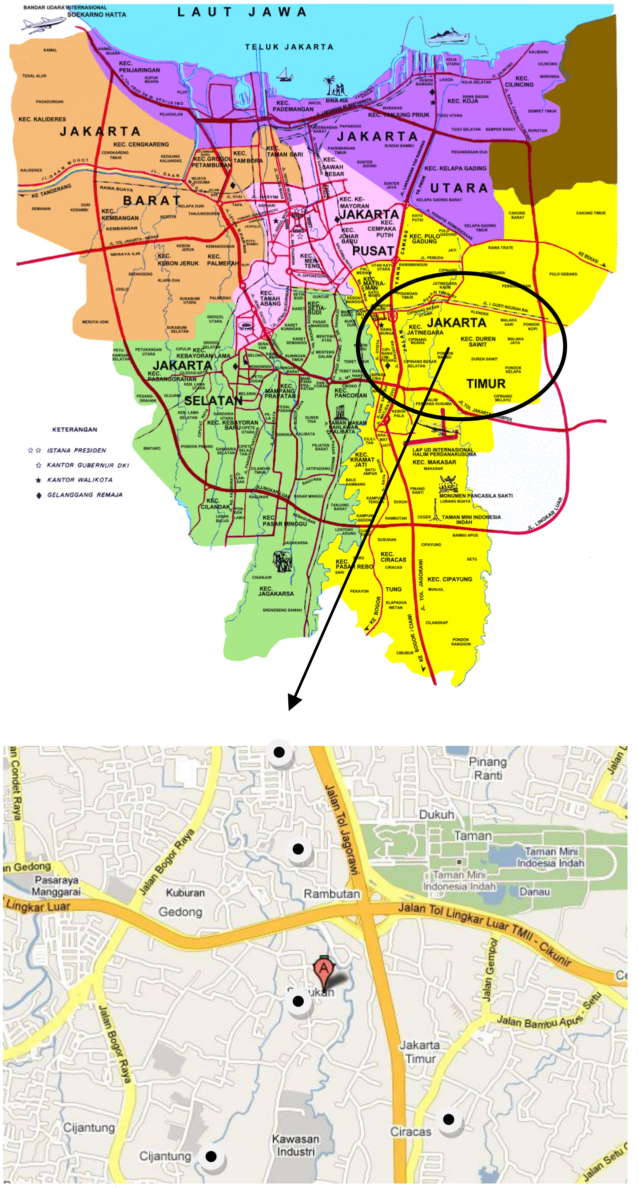

Fig. 1. Map of study area in East Jakarta, Indonesia showing sampling sites

Data was analyzed using One way *Anova* to compare each location with different land uses and concentration of Fe and Mn, and fecal bacteria (concentration of *Coliform* and *E. coli*). All data then were compared to the standard created by the Decree of Health Minister of Indonesia (DHMI) No. 907 year 2002 [8] about drinking water quality requirements and The Regulation of Health Minister of Indonesia (RHMI) No. 416 year 1990 [9] about Water Quality Standard. This is important to know whether the water is drinkable or not.

III. Results and Discussion

A. The Content of Coliform and E. coli in Ground Water

Most of groundwater at Ciracas sub-district was already contaminated by *Coliform* and *E. coli* (Table I). It was showed by the presence of *Coliform* and *E.coli* in groundwater which should be none of them was there (based on DHMI No. 907 year 2002). *Coliform* and *E. coli* were found at most of the study sites, except SG site. This showed that the groundwater was not able to be used as drinking water based on the standard of DHMI No. 907/2002 [8] and RHMI No. 416 year 1990 [9] which should be zero counts. *Coliform* and *E. coli* counts in groundwater ranged was from 18-26000 MPN/100 ml sample and 1,8-6790 MPN/100 ml sample. In *Anova* results, it showed significant difference in each land uses at study sites and concentration of *Coliform* and *E. coli* (p<0.05). The highest *Coliform* concentration was in Ciracas sub-district whereas Susukan sub-district with the highest *E. coli* concentration.

TABLE I: Content of Coliform and *E.coli* Bacteria (MPN/100 ml Sample)

Location	Former Land	Code	*Coliform*	*E coli*	Note
Ciracas	Swamp	CS	26000	5150	not drinkable
	Rice Field	CRF	475	330	not drinkable
	Garden	CG	155	14	not drinkable
Susukan	Swamp	SS	132	72	not drinkable
	Rice Field	SRF	17620	6790	not drinkable
	Garden	SG	0	0	not drinkable
Kampung Rambutan	Swamp	KrS	7300	1320	not drinkable
	Rice Field	KrRF	18	13	not drinkable
	Garden	KrG	12250	2200	not drinkable
Kelapa Dua Wetan	Swamp	KdS	20	1.8	not drinkable
	Rice Field	KdRF	5700	2000	not drinkable
	Garden	KdG	1520	1800	not drinkable
Cibubur	Swamp	CbS	140	9.25	not drinkable
	Rice Field	CbRF	1950	330	not drinkable
	Garden	CbG	515	64	not drinkable

Water containing *coli* group was deemed to human feces contaminated. Contaminated water generally has high level of organic matters that contains many heterotrophic microorganisms. Heterotrophic microorganisms will use them for their metabolism process, such as *Coliform* bacteria [3], [10], [11].

The presence of *Coliform* and *E. coli* bacteria in each sample of ground water was assumed due to the densely populated residential area, where the distance of wells is in the adjacent with bathroom and septic tank. The distance should be > 10 m [12]. It was assumed that distribution of bacteria still occurred up to a distance of 11 m, so that the distance should be at least 12 m [13]. In Ciracas sub-district, most of well and septic tank distance were not in accordance with the standard, only 6 wells were more than 10 m (Table II). Thus, it was found that most of groundwater at Ciracas sub-district was already contaminated by *Coliform* and *E.coli* bacteria in a high level. This also occured at South Jakarta district ranging from 3 to 160 MPN/100 ml of *E.coli* [5].

TABLE II: DISTANCE OF WELL TO SEPTIC TANK

Location	Well Type	Age (year)	Depth (m)	Distance of Well to Septic Tank (m)
CS	Drilled	23	20	10
CRF	Drilled	14	12	8
CG	Excavated	18	15	12
SS	Drilled	22	30	20
SRF	Drilled	10	15	11
SG	Drilled	7	23	6
KrS	Drilled	23	11	13
KrRF	Drilled	3	11	10
KrG	Excavated	20	20	7
KdS	Drilled	2	30	20
KdRF	Drilled	8	15	10
KdG	Drilled	19	12	17
CbS	Drilled	25	16	10
CbRF	Excavated	25	15	5
CbG	Drilled	37	15	7

Dense settlements cause the difficulty to get the ideal distance of wells with septic tank for appropriate health requirements. The ideal distance of wells with septic tank sometimes can be fulfilled in one house, but it is not with neighbors's wells and septic tank distance. Nevertheless, there was no significant correlation between the distance of wells and septic tank with conscentration of *Coliform* and *E. coli* (p>0,05). Kosasih *et al* [5] stated that well depth was statistically correlated with concentration of *Coliform* and *E. coli*. Harmayani and Konsukartha [7] was also mentioned the same condition at Banjar Ubung, Bali which was different from the result of this study. It assumed that contamination of well water from septic tank seepage was more reasonable for the presence of fecal bacteria. The other, sucking feces in septic tank regularly could reduce fecal bacteria counts.

B. Iron and Manganese Concentration in Well Water

It was known that only SG was not found bacteria contamination, although the well-septic tank distance was less than 11 m. This could be caused by the former land of garden which contains more inorganic substances. As shown in Figure 2, SG had higher manganese concentration than other study sites, that was 2.25 mg/L. According Bawahab and Isnawati [14], manganese was dissolved in oxygen-poor surface water. Thus, higher concentration of manganese might indicate less oxygen in water which microorganisms were difficult to grow eventually.

Almost 80% of study sites had 0.3 mg/L of Fe less than the standards of DHMI No. 907 year 2002 and RHMI No. 416 year 1990. Only 3 sites had higher Fe content in groundwater, SRF, KrRF, and KdRF which were not safe for consumption as drinking water. This could be due to the former land of rice field in those areas where contained a lot of inorganic substances derived from the use of pesticides and fertilizers during cultivation activities. If the inorganic compounds come into the aquatic environment, it will elevate the amount of metal ions in water [15], [16].

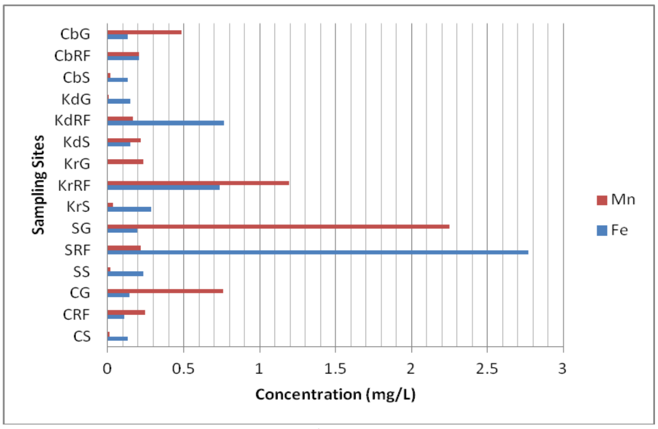

Fig. 2. Concentration of Fe and Mn in well water

Soluble iron at low pH can cause yellowing of the water, which causes stains on clothing and bacterial proliferation, namely *Creonothrinx* (iron bacteria). Therefore iron content should not exceed 1 mg/L as it can accelerate the growth of iron bacteria and can cause taste and odor in water (Sutrisno, 2004). Location SG had the highest Fe content (2.77 mg/L), and this can be explained why the water was slightly yellowish in color, smell and taste of iron metal.

Meanwhile, approximately 67% of wells contained high concentration of Mn that exceeds the standards of DHMI No. 907 year 2002 and RHMI No. 416 year 1990, which requires maximum concentration value of 0.1 mg Mn/L. Only 5 sites had lower concentration of Mn in groundwater. According to Sutrisno [3], if Mn concentration was greater than 0.5 mg/L, it can cause a strange taste in drinking water and leave the chocolate-brown color of the clothes washing. For health, it is a toxic substance which can cause liver damage and respiratory disturbance.

The highest concentration of Mn was found in the former land of rice field and garden which was apparently derived from pesticides residues and fertilizers used during plantation activities [15]. While former swamp showed low concentration of Mn which was below the standard value (0.1 mg / L). This was apparently because of the large quantity of organic compouds which was easily degraded by microorganisms [11]. Therefore, the location of former swamp had large number of *Coliform* and *E. coli* (Table I).

The physical parameter such as pH and conductivity value also affected the concentration of Fe and Mn. The result showed that there were 2 sites (SRF and KrRF) with lower value of pH, below the standard of 6,5, and high conductivity values, 0.71 and 0.73 s/cm. It could caused higher concentration of Fe and Mn due to leaching of metals and corrosion in water body [17]. The conductivity values in water can indicate the large number of metals that are dissolved in water [18]. Presumably this is other factor that led to higher concentration of Fe or Mn at both study sites.

Most of study sites contained iron and manganese. According to Bahawab and Isnawati [14], manganese and iron are metal substances widely encountered in the Earth's crust. Higher concentration of iron and manganese usually occur in the older and deeper wells. Because the deeper wells, the higher CO_2 concentration and the lower O_2 content, further it can be zero. This anaerobic condition will increase the solubility of Fe^{2+} and Mn^{2+} in ground water which resulting in increased iron and manganese in water [2]. Nevertheless, the results of this study showed the opposite. The older age wells (37 years) and the deeper wells (30 m) did not had the highest concentration of Fe and Mn. This could be caused by the interaction of microorganisms and organic materials in former land uses.

According to Darmono [19], metal content in water can be changed and highly dependent on the environment and climate condition. In rainy season, the metal content will be lower because the metal dissolution process. Whereas the metal content in the dry season will be higher because the metal becomes concentrated.

Groundwater contaminated with Fe and Mn should be treated to reduce the concentration of organic and inorganic compounds based on the standards. Drinking water use has to meet the standard of drinking water quality in order to avoid health problems. Contamination of fecal bacteria in drinking water has to be avoided by heating the water in 80-100 ℃ to kill bacteria. According to Alamsyah [20], chemical treatment for groundwater can be done through coagulation process using chemicals and aeration process. Other treatment is by physical methods, which are: 1) Filtering, 2) Precipitation, providing materials coagulant, 3) Absorption, using materials such as activated carbon to absorb the particles, and 4) Adsorption, the process of catching the ions contained in water.

IV. Conclusions

Most of groundwater at Ciracas sub-district has been polluted by *Coliform* dan *E. coli* bacterias. Less location of Ciracas sub-district showed water contaminated by Fe and Mn. Therefore, based on microbial and chemical analysis, the groundwater in Ciracas sub-district was not safe for drinking water according to water quality standards of DHMI No. 907 year 2002 and RHMI No. 416 year 1990.

For drinking water use, the groundwater has to be boiled in 100^oC pretreated to kill bacteria and filtration process to remove turbidity. The use of purchased treatment water (government drinking water treatment company) is recommended, although it is more expensive, but it is good for health. Nevertheless, the more important is to reduce population density and urbanisation to urban area, such as Jakarta. Besides, prevention and awareness is the best way to prevent ground water contamination. This can be achieved by individual and group actions of society so that groundwater is sustained and can be used by the next generation.

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