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Analysis of Bacterial Contaminant in Pasir Gudang, Johor Tap Water Supply–Varies pH Value Observation

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ABSTRACT

The number of breakthrough pathogenic activity in water distribution network system is constantly increasing day by day especially at level of consumption. Bacterial growth or survival rate often relates to acidity and alkalinity of water. Sudden changes in pH value and temperature indicates a possibility of present bacterial contaminant in aqueous environment. The observation of pH- and temperature-based for tap water supply samples in Pasir Gudang regions therefore was determined. On the basis of the findings, the observed pH value was compared to the recommended range for pH tap and drinking water, which is between 6.5-8.5. A significant spread can be seen among the measured parameters within the range of pH and temperature at 6.00 to 8.65 and 19.20 to 32.00 °C, respectively. There is a statistically significant difference between each sampling regions based on the measured pH value ($DF_{4,145} = 44.79$, $p < 0.05$) determined by one-way ANOVA. The pH value and temperature evidence a significant effects by the location of tap water samples near industrial regions. There also appears to be a negative Pearson correlation between the two water parameters in four out of five regions.

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NOMENCLATURE

H_2O	Water	N	Number of Observations
H^+	Hydrogen	μ	Mean
OH^-	Hydroxide	σ	Standard Deviation
K_c	Equilibrium constant	r	Correlation
K_w	Auto ionization constant	p	Probability value
DF	Degree of Freedom	F	Snedecor's F distribution

1. INTRODUCTION

Contaminated water supply has been the main concern in many countries, including Asia. According to Asian Water Development Outlook 2016, the world's fastest-growing economy are living in a water-stressed condition, posing a water-insecure threats to the region's population [1]. The majority of Asia's population does not have access to clean and safe household water supply. Based on the National Water Security Index, countries including Malaysia, South Korea, Japan and Singapore are listed in the level 3 index number indicating the process of building secure water supply for their people [2]. The presence of some microorganism activity in water ecology may indicate the possibility of contamination and water quality deterioration. The breakthrough of various pathogens such as bacteria, virus and parasites in water distribution pipeline system has increased day by day. This is due to the expansion of industrialization, growth of human activities, countless of sewages being exerted from facilities and climate changes. High concentration of microbiological contaminants in water supply may cause severe human health effects [3]. Treated water supply are distributed through the water distribution

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system (WDS) which are used virtually for all the human needs. However, water quality may deteriorate extensively during transportation from treatment facility to level of consumption. Water-based *Legionella* and non-tuberculous mycobacteria has been regularly found at exposure points which prevail human health concerns [4].

The microbiological activity in distribution system are influenced by two environmental conditions which are suspended microorganism in bulk water and those in biofilms from surface of pipes or sediments. Microorganism breakdown occurs through bacterial growth in treatment filters, biofilms attached to distribution system, water recontamination resulted from pipe breaks or external intrusion. Meanwhile, biofilms microbes is originates from organisms present in pipe surfaces during installation process. The nature of the surface pipeline material have a strong influence on the production of microbial activity in water supply [5, 6]. Previously, study has shown that the growth of biofilms microbes increases on corrosion-controlled iron pipe surfaces compared to plastic polyvinyl chloride (PVC) pipes [7]. Microbial population are to be found more frequently in iron pipes distribution system [8]. Certain bacterial growth are closely related to certain type of material pipelines system because some material may contains compound that support their productivity. For instance, pipe sections, fittings, valves and elastic sealants can provide nutrients for bacterial population. Some of these nutrients are distributed from food production industries, such as dairy products, which enhance microorganism activities [9].

Failures at treatment level or water pipeline system contamination could results an existence of various pathogenic microbes in tap water supply. There have been several study on pathogenic contamination events within distribution system biofilms [10]. For example, bacterial pathogens such as *Cryptosporidium*, *Helicobacter pylori*, *Escherichia coli*, *Campylobacter spp*. and *Salmonella typhimurium* can be trapped in biofilms after contamination event occurred [11-14]. The formation of these microbes in an actual full-scale distribution pipeline system will eventually dissipates from biofilms but the significant timeframe of their persistence is unknown. An adoption of uniform measures should be put in place to ensure sufficient data set and accurate detection of bacteria, especially at level of consumption. Treated as well as untreated water supply are most likely contains some level of pathogens if not all of the time. The population dynamics of bacteria released in aqueous environments inherent an assumption that all requirements for their growth are effected by macronutrients, micronutrients, temperature, pH, salinity and oxygen. Bacteria has the ability to adopt in climate changes, in which transformation of their physical changes to a non-cultivable state become favorable for growth. Previously, a study on the exponential growth of *Escherichia coli* shows the heat shock response to the environmental shift from alkaline to acid condition [15-17]. Most of the microorganism present in aqueous environment are acidic-tolerance microbes. This is shown in a work by Zhao *et al*. [18] that some pathogens are able to present in acidic conditions within pH range of 3.6 to 4.0. Supporting this, previous work has shown a significant microbial growth rate in acidic [19].

Given the recent emergence of bacterial contaminants in tap water supply, there is the need to identify and quantify any bacterial activity based on the range of water pH level and temperature under the influence of varies environmental condition. However, this is still yet ambiguous due to various existence of bacterial contamination in water supply. One could not conclude that the exact water sample is contaminated with specified bacteria. The goal of this screening study, therefore, was to observe the changes in pH and temperature of tap water supply at different location and timeframe. Specifically, the objectives were to analyse any possibility of five targeted bacteria, which are *E. coli*, *Legionella* spp., *Salmonella enterica*, *Pseudomonas aeruginosa* and *Naegleria fowleri*, potential to present in water samples at level of consumption based on measured water pH and temperature. In addition to that, these water sample were to determine whether it is within the acceptable pH level provided by EPA [20]. Results obtained verified whether this selected region can be used for further analysis on presence of potential bacterial contaminants in tap water supply within varies timeframe. In addition, pH and temperature is the most crucial chemical property of water that is relative to acidity or alkalinity. It must be firstly examined upon water sampling procedure.

2. METHODOLOGY

2. 1. Scope Area and Sampling Sites The study of water sample were during the peak of rainy season in Malaysia. This screening study was conducted within the region of Pasir Gudang, Johor, Malaysia. Water samples were collected in five location of water municipal within the region of Pasir Gudang, known to be an industrial town located at Mukim Plentong, Johor Bahru, Malaysia. This area was purposely chosen due to its very rapid urbanization and industrialization.

There are five regions which represent different water source municipal. The population and location areas are based on the quantitative measures provided by the Pasir Gudang Municipal Council [21]. The distance of each region from Pasir Gudang industrial area, specifically from the IOI Loders Croklaan Asia / IOI Lipid Enzymtec, was obtained (Table 1).

TABLE 1. Water sampling regions

Water Municipal	Population	Immensity (hectare)	Distance (km)
Region A (WM01)	11900	120	6.0
Region B (WM02)	13500	260	2.8
Region C (WM03)	14700	186	8.1
Region D (WM04)	11800	280	5.9
Region E (WM05)	15100	96	7.6

2. 2. Sample Preparation The sampling of tap water follows the guidelines for water and wastewater sampling methods [22-24]. Samples taken represents of the different sources from which water is obtained publically. Sampling regime using random sites is more likely to detect local contaminants. Particularly, sampling points are based on uniformly distributed piped system by taking account the population distribution.

The number of samples follow the guidelines of minimum sample numbers for piped drinking-water in the distribution system [25]. Minimum sample numbers for piped-water in distribution system are based on population in which the water supply served. For a population that is greater than 100,000, number of monthly samples are 1 per 10,000 populations, plus 10 additional samples. Hence, following this guidelines, 30 tap water samples were collected in each selected sampling regions. This is to ensure that the water supplied to consumers has similar piped water supply network and sufficient data set could be observed accurately. Housing nearby industrial areas were chosen randomly to observe pH value and water temperature for 150 locations with varies of water municipal.

In each targeted location, 100 mL was sampled in a sterilized laboratory glass bottle, which is the standard requirement for microbiological analysis in water sample [26]. For piped water samples, water was allowed to run at least 1 min before sample were collected. This is to ensure that water collected has been in contact with the distribution system pipes for at least six hours.

2. 3. Examination of Water Samples The water samples collected were immediately examined on-site during sampling process. No storage or any preservation steps was required. The measurement of water pH and temperature was recorded upon sample collection. The standard measurement method for pH value in water quality is by using electrometrical glass electrode [27]. Measurement of pH value was recorded using a Semlos 0.01 resolution digital pH meter pen. This handheld device is used for determining the acidity or alkalinity of liquids samples with measuring range from 0.00 to 14.00 pH. The device was initially calibrated with a pH buffer powder solution of 4.01 and 6.86 at 25°C, respectively. As for water temperature measurement, the HI98501 Checktemp® Digital Thermometer by Hanna® instruments was used. Featuring an accuracy of ±0.2°C and resolution of 0.1°C, the HI98501 model provides accurate reading of temperature ranging from -50.0 to 150.0°C. The CAL Check™ features enable automatic device calibration upon startup. The temperature was recorded at time of sampling. This is to ensure that temperature of the water sample should not change by more than 5°C before analysis. Both electrode devices were rinsed with distilled water for each sample measurement.

Taken into account the endothermic process in a formation of hydrogen (hydroxonium ions) and hydroxide ions from water, the forward reaction shown in Equation 1 absorbs heat.

$$H_2O_{(l)} \leftrightharpoons H^+_{(aq)} + OH^-_{(aq)} \quad (1)$$

The auto-disassociation of water is given:

$$2H_2O + heat \leftrightharpoons H_3O^+ + OH^- \quad (2)$$

According to the Le Châtelier's Principle, the changes in temperature affect equilibrium conditions. The position of equilibrium will be shift to the left to absorb heat, hence increase the temperature. This is similar to reducing the temperature, where an exothermic reaction occurs. According to the equilibrium law,

$$K_c = [H^+]\ [H_2O]\ [OH^-] \quad (3)$$

In equilibrium condition, the concentration of the water remains constant in both sides, hence a very close approximation in the term $[H_2O]$ can be removed and equilibrium constant is defined as K_w. Given by:

$$K_w = [H^+][OH^-] \quad (4)$$

In most natural water, the pH value is controlled by the acid-based equilibrium and carbon dioxide-bicarbonate-carbonate equilibrium system. Any present of excessive hydrogen ion concentration in water will therefore affects the pH value. Sudden changes in pH values indicate any outbreak of possible microorganism contaminants that requires further investigation [28]. Generally, the pH of a solution is known as the negative logarithm of hydrogen ion activity (Equation 5).

$$pH = -\log (H^+) \quad (5)$$

Considering the disassociation of water in each equation, when temperature is increased, based on the Le Châtelier's Principle, the concentration of H_3O^+, also known as H^+, and OH^- ions will also increase. Therefore, indicates the increment of K_w value, which is the function of temperature and decrement of pH value.

2. 4. Data Analysis In this screening study, skewness and kurtosis [23] have used since analysis of environmental study will not be normally distributed in many cases. Skewness and kurtosis [23] also used to test the normality and to determine the value of bell-shaped distribution. It determines the degree of asymmetry of the distribution around its mean. Presented results were obtained using several different statistical approach in similar research field such as descriptive statistical analyses [29-31], one-way ANOVA [32, 33] and Pearson correlation were used to analyze the relationship between two water quality parameters. Data recording and analysis was made using SPSS package version 23. Using the statistical method and graphical test, an analysis of the normality of each variable is conducted.

3. RESULTS AND DISCUSSION

3. 1. Normality Test Histogram analysis in this screening study presents a skewed (non-symmetric) distribution. According to the rule of thumb, the values of asymmetry and kurtosis is within the limit of ±2 and considered acceptable to prove a normal univariate distribution [34, 35]. The mean difference is significant at p-values greater than 0.05 level ($p > 0.05$).
Table 2 presents the summary of normality test for this study. Data point were showed skewed to the right if the skewness was a positive value and vice versa.

3. 2. Distribution of Water pH and Temperature The descriptive results on pH and temperatures is summarized in Table 3. Region WM03 showed the highest pH value of 7.99±0.45, while the lowest pH was found at location WM04 at 6.93±0.45. Region WM03 also showed highest water temperature at 27.46±2.33 °C. However, the lowest water temperature obtained was at region WM01 with 23.38±1.57 °C.

TABLE 2. Normality test

		pH	T (°C)
N	Valid	150	150
Skewness		0.309	0.440
Std. Error of Skewness		0.198	0.198
Kurtosis		-0.908	0.061
Std. Error of Kurtosis		0.394	0.394

TABLE 3. Descriptive results on pH and temperature based on different regions

	Regions				
	WM01	WM02	WM03	WM04	WM05
pH					
μ	6.96	6.72	7.99	6.93	7.71
σ	0.44	0.24	0.45	0.45	0.61
Min.	6.00	6.34	7.05	6.10	6.36
Max.	7.66	7.11	8.57	7.77	8.05
°C					
μ	23.38	26.35	27.46	23.44	25.15
σ	1.57	2.99	2.33	3.00	2.28
Min.	19.70	19.40	23.90	19.20	22.10
Max.	26.70	32.00	31.90	31.80	32.10

Figure 1 shows the relationship between water pH and temperature measured at different location. In this study, the relationship between pH and temperature of water samples is investigated. A significant spread can be seen among the measured parameters within the range of pH and temperature at 6.72 to 7.71 and 23.38 to 27.46 °C, respectively. Overall, the observed pH value was compared to the recommended range for pH tap and drinking water, which is 6.5-8.5, hence it is considered an acceptable value [36]. Interestingly, there is a significant exponentially decrease pattern of outliers between pH and temperature in water samples indicating an increment of temperature results a decrement of pH value which water are in a form of acidic. These outliers are considered value of parameter that is not within the acceptable range of water quality. In an environmental study, outliers should not be rejected arbitrarily since high and low concentration of contamination may occurs at different areas [23].

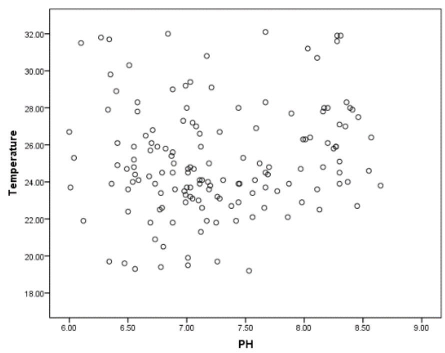

Figure 1. Scatter plot for the measured pH and temperature

From the observation, approximately 11% of the tap water sample was not within the standard requirement of tap and drinking water quality, with pH level ranging between 6.00 to 6.49. It should be noted that any water samples below the minimum acceptable pH level is considered contaminated and hazardous for human consumption. In this study, a case-to-case approach is necessity and could not be generalized since microbiological contaminants could present at different timeframe. The measured pH value is compared to the survival of five targeted bacteria within the range of pH level summarized in Table 5. The pH value for the survival of five targeted bacteria in tap water is within the range from 4.4 to 9.5. Taken into account the distance of water sampling from industrial area (Table 1), the closest is 2.8 km at Region B. The second closest sampling region is WM04. During the course of this study, the pH distribution at region WM02 and WM04 has the highest frequency of pH value that is less than 6.5 (Table 4). Owing the fact that pathogens can enter distribution network system via variety of pathways (i.e. leaking pipes, cross-connections, finished water storage vessels and inadequate distribution system security), water quality may deteriorate due to the discharge of harmful chemicals compound from industries into distribution network system which is near to the infrastructure. In this case is region WM02 and WM04. Industrial areas are known as the “zone of contribution” to water pollution. Water contamination is more likely to occur due to exposures of waste production from industrial wastes [37]. An important source of contamination in water supply is runoff water from urban areas.

Lowest pH value was evident in region WM01 with pH 6.00 at 26.70 °C. Similarly, different location at region WM01 continues to show existence of acidic water supply having a pH value of 6.01 and 6.04 at 23.70 °C and 25.30 °C, respectively. Significantly, WM02 and WM04 shows the highest distribution of acidic water supply ranging from pH 6.34-6.49 and 6.10-6.47, respectively. Only one location of tap water source in region WM05 indicating a pH 6.36 at 23.90 °C. During storms or rainy days, rainwater flows across exposed land and water surfaces, allowing transmission of contaminants. The mobilization of contaminants generally increases during rainy seasons. These contaminants are carried in runoff from various industrial nonpoint sources. Contaminants that are commonly found in storm water runoff includes pathogenic bacteria [38]. Interestingly, in region WM03 shows no significant pH value that is less than 6.5. Hence, the water distribution system in region WM03 is considered safe to be used for human consumption. However, there is the possibility of bacteria contaminant presence in water since survival rate of bacteria is also enhanced by low temperatures, high soil humidity and

TABLE 4. Measurement of pH value less than 6.5 based on different sampling region

Location	Tap water sample	Parameter	
		pH	°C
WM01	SL14	6.01	23.70
	SL15	6.04	25.30
	SL16	6.00	26.70
WM02	SL07	6.41	26.10
	SL11	6.49	24.70
	SL12	6.34	31.70
	SL13	6.40	28.90
	SL15	6.35	29.80
	SL16	6.41	24.90
WM04	SL06	6.34	19.70
	SL10	6.12	21.90
	SL11	6.27	31.80
	SL12	6.10	31.50
	SL13	6.33	27.90
	SL14	6.47	19.60
WM05	SL12	6.36	23.90

TABLE 5. The survival of targeted bacteria in water environment based on the pH range [39-41]

Bacteria	Minimum	Optimum	Maximum
E. coli	4.4	6.0 – 7.0	9.0
Legionella spp.	5.0	6.0 – 8.0	8.5
Salmonella enterica	4.2	7.0 – 7.5	9.5
Pseudomonas aeruginosa	5.6	6.6 – 7.0	8.0
Naegleria fowleri	4.6	6.0 – 6.5	8.0

alkaline pH.. The highest pH value observed was in region WM05 with pH 8.65 at 23.80 °C and followed by pH 8.57 at 26.40 °C in region WM03. Potentially, bacteria may present in tap water under alkaline environment which is shown in Table 5 indicating the maximum range of possible bacteria contaminants is at pH 9.5, which are almost similar as previous finding [42].

3. 3. Analysis of Variance One-way ANOVA was conducted to determine any statistically significant mean difference between the sampling regions based on measured pH value. Table 6 summarized the results of one-way ANOVA approach. The *F*-value is significantly enough to reject the null hypothesis. Based on Table 6, there is a statistically significant difference

TABLE 6. One-way ANOVA based on different regions

Region	*N*	*μ*	σ	*F*	Sig.
WM01	30	6.96	0.44		
WM02	30	6.72	0.24		
WM03	30	7.99	0.45	44.792	.000
WM04	30	6.93	0.45		
WM05	30	7.71	0.61		

$DF_{4,145} = 44.79, p < 0.05$

between each sampling regions based on the measured pH value ($DF_{4,145} = 44.79$, $p < 0.05$) determined by one-way ANOVA. The value of pH at region WM03 (7.99±0.45) is significantly higher than value of pH at region WM01 (6.96±0.44), WM02 (6.72±0.24) and WM04 (6.93±0.45). Similarly, the value of pH at region WM05 (7.71±0.61) is significantly higher than region WM01 (6.96±0.44), WM02 (6.72±0.24) and WM04 (6.93±0.45).

By using the Bonferroni post-hoc test, the mean differences between the values of pH in each regions are proven to be statistically significant at the 0.05 level. It can be observed that the biggest difference is between region WM03 and WM02 having a mean difference of 1.269. Whilst the smallest difference is between region WM01 and WM05, where the mean difference is 0.758. It was found that the farthest distance of sampling location from industrial area displayed the highest water pH level. Hence, this difference is due to a higher pH value as a consequences of highest sampling location distance from industrial area.

3. 4. Pearson correlation analysis A Pearson correlation analysis was conducted to define the relationship between measured pH and temperature of water samples based on Le Châtelier's Principle described in previous section (Tables 7-11). The temperature and pH are measured on each location of water sample. These pair of variable is frequently of interest to establish any relationship observed between pH and temperature.

TABLE 7. Correlations WM01

		pH	T (°C)
pH	Pearson Correlation	1	-0.352
	Sig. (2-tailed)		0.057
	N	30	30
T (°C)	Pearson Correlation	-0.352	1
Sig. (2-tailed)		0.057	
N		30	30

TABLE 8. Correlations WM02

		pH	T (°C)
pH	Pearson Correlation	1	-0.207
	Sig. (2-tailed)		0.272
	N	30	30
T (°C)	Pearson Correlation	-0.207	1
Sig. (2-tailed)		0.272	
N		30	30

TABLE 9. Correlations WM03

		pH	T (°C)
pH	Pearson Correlation	1	0.068
	Sig. (2-tailed)		0.723
	N	30	30
T (°C)	Pearson Correlation	0.068	1
Sig. (2-tailed)		0.723	
N		30	30

TABLE 10. Correlations WM04

		pH	T (°C)
pH	Pearson Correlation	1	-0.334
	Sig. (2-tailed)		0.072
	N	30	30
T (°C)	Pearson Correlation	-0.334	1
Sig. (2-tailed)		0.072	
N		30	30

TABLE 11. Correlations WM05

		pH	T (°C)
pH	Pearson Correlation	1	-0.067
	Sig. (2-tailed)		0.724
	N	30	30
T (°C)	Pearson Correlation	-0.067	1
Sig. (2-tailed)		0.724	
N		30	30

Based on the Pearson correlation analysis, there appears to be a negative correlation between the two variables in region WM01 ($r = -0.352, p > 0.05$), WM02 ($r = -0.207, p > 0.05$), WM04 ($r = -0.334, p > 0.05$) and WM05 ($r = -0.21, p > 0.05$). Interestingly, only in region WM03 ($r = 0.068, p > 0.05$) indicate a positive correlation between the measured temperature and pH. The strength of the correlation in each region is define as an absolute value if *r* using the guidance provided in previous work [43]. The correlation of two variables in region WM01, WM02, WM04 and WM05 indicates a weak negative correlation where the value of *r* is between -0.20 to -0.39. Cleary, this trend suggest the water temperature has a tendency to increase over a lower pH value. Therefore, the result follows the theoretical relationship between pH and temperature as described in previous section. However, the value of *r* in region WM05 resulted a very weak positive correlation, which is within the range of 0.00 to 0.19. Based on the results obtained, it is therefore perfectly possible to conclude that there is a weak linear relationship between measured pH and temperature, where *r* is considered close to 0 in both positive and negative correlation.

4. CONCLUSION

This screening study investigate water quality at level of consumption, which is tap water samples, of urban communities. Overall, the results of statistical analysis denote a plausible relationship between pH, temperature and environmental conditions. Pasir Gudang region is known to be the heavy industrial areas which use water directly from available water source and therefore potentially been exposed to various pathogenic bacteria. One of the most interesting observations was the significant difference of measured water pH and temperature in different location within the regions, whilst having the same water municipal. It appears that the trend of these findings show water is more acidic in region close to industrial areas, in this case is WM02 and WM04. Meanwhile, regions that are the farthest shows high alkalinity pH water such in WM03 with distance of 8.1 km. A one-way ANOVA shows a significant mean difference between each sampling regions based on the measured pH value ($DF_{4,145} = 44.79,\ p < 0.05$). The results were validated by conducting a Bonferroni post-hoc test and proven to be statistically significant at the 0.05 level. Based on the *F*-value= 44.792, the null hypothesis is rejected at a significance of 0.000 ($p < 0.05$). On the basis of these findings, observation of pH and temperature measured in housing clearly indicates that water in distribution network system could be affected by industrial infrastructure such as oil refinery, heavy industrial supplier, food production, steel and metal fabricator. Therefore, it seems to be logical to suggest that bacterial contaminants in housing near industrial areas should be monitored in regular basis and water quality assessment need to be conducted individually.

Results of statistical analysis clearly showed that, in rainy season, runoff decreases the pH value of water samples. Tap water has the tendency to be more acidic within temperature ranging from 19.60 °C to 31.80 °C. In practice, water parameters (pH and temperature) does not primarily influenced from one another. The study of causation based on the observed trend possibly indicates an existence of a third variable (i.e. air temperature, humidity etc.). Based on the scatter diagram, evidence shows a skewed distribution and various existence of outliers. This clear effects the Pearson’s correlation coefficient pragmatically rather than theoretically. The outcome of this screening study validates whether further analysis on tap water sample in Pasir Gudang regions could be conducted efficiently. Based on the results of measured pH, acidity and alkalinity of water samples are within the range of survival rate of five targeted bacteria, in this case is *E. coli*, *Legionella spp.*, *Salmonella enterica*, *Pseudomonas aeruginosa* and *Naegleria fowleri.*

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Analysis of Bacterial Contaminant in Pasir Gudang, Johor Tap Water Supply–Varies pH Value Observation

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چکیده

تعداد دستیابی به فعالیت های بیماری زا در سیستم شبکه توزیع آب همواره روز به روز به خصوص در سطح مصرف رو به افزایش است. نرخ بقا و یا رشد باکتریایی اغلب مربوط به تولید آب است. تغییرات ناگهانی در مقدار *pH* و دما را نشان می دهد احتمال این آلاینده باکتری در محیط آبی. مشاهده از *pH* و دما–بر اساس نمونه تامین آب در مناطق *Pasir Gudang* بنابراین گردید. بر اساس یافته ها، مقدار *pH* مشاهده نسبت به محدوده توصیه می شود برای *pH* شیر و آب که بین 6.5 تا 8.5 بود. گسترش قابل توجهی میان پارامترهای اندازه گیری در محدوده *pH* و دما در 8.65-6.00 و 32.00–19.20 درجه سانتیگراد بود دیده می شود. تفاوت معنی داری بین مناطق نمونه هر براساس مقدار اندازه گیری *pH* وجود دارد *(DF_4 145 = 44.79 p-0.05)* واریانس یک طرفه مشخص. مقدار *pH* و دما نشان دهنده تأثیر قابل توجهی از محل نمونه های شیر آب در مناطق صنعتی است. همچنین بین دو پارامتر آب در چهار منطقه از پنج منطقه منفی همبستگی پیرسون وجود دارد.

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