Quick-and-Simple *Escherichia coli* Test Strip for Locally Tailor Made Water Quality Information in Community Development and Empowerment Program

Fitria Nurul Mutmainah, Akira Kikuchi, and Romaidi

***Abstract*—**Awareness of pathogenic bacteria contamination in water is one of community's daily life problems that expected can be solve by community development and empowerment program. However, method must be applicable and acceptable for the public. Hence, we concern on locally tailor by simple and rapid method to determine *E. coli* contamination handled by non-specialist with quick-and-simple test strips. The check kit has detection limit for several hundred *E. coli* contaminations per 100 ml water sample.

An exploratory survey was performed taking an example in Dempok hamlet, Malang and Caruban, Madiun, Indonesia. Test strip was easy-to-use and successfully handle by non-specialist. It was accepted of giving the actual data for indicating generally existing moderate *E. coli* contamination in community's daily life water. Therefore, test strip method was quick-and-simple environmental education program that can handle by non-specialist without any laboratory equipment. Toward the next step, a potential device was designed to implement affordable *E. coli* testing capacity in Community Development and Empowerment Programs.

***Keywords*—** Community Development and Empowerment Program, *E. coli* contamination, Environmental Education, Quick-and-Simple detection Method

I. Introduction

WATER sustain all life on earth. As one of the basic elements of the natural environment, water is a consumable item for humans and animals, primary component for industry and a vector for domestic and industrial pollution [1]. The problem of water supply becomes one of the priorities in the improvement of the health of society [2]. With increasing population density and rapid development, the need for water is increased.

The associated risk for pathogen contaminated water consumption is one of the great concerns for health perspective in the world [1]. Water-related outbreaks of disease are frequently caused by the consumption of water that is contaminated with human or animal fecal material. *Escherichia coli* are used as indicator of water (un)safety regarding fecal contamination in almost all water quality legislation in the world. It is the microbiological parameter that is most frequently monitored in drinking water and bathing water surveillance *E. coli* is a bacterium that resides in high numbers in the intestines of warm-blooded animals and has proven its value to detect fecal contamination in water [4].

According to [5], good quality (<1 *E. coli* per 100 ml) and moderately contaminated (2-100 *E. coli* per 100 ml) children's drinking water has little difference for illness rates on children, respectively. Thereby, children's drinking water with > 1000 *E. coli* per 100 ml had significantly higher rates of diarrhea disease than those drinking less contaminated water. As a risk management indicator, international drinking water standards and guidelines do state no *E. coli* contamination

In Indonesia, the infrastructural capacity for chlorinated pipe water is limited for country side, where many people consume shallow groundwater and river water for daily life. Subsequently, on demand assessment and mitigation of the pathogen contamination risk make sense to preserve human health. Though, if the application of standard method is only compulsory for water quality testing, due to the high cost, sufficient resolution of data is not available in time and space. Besides, the analysis is only by specialists that depend on laboratory facilities. On the other hand, on demand tailor-made information is enabled once wider flexibility of monitoring methods is purposely accepted [5].

Our focus is using a fast and simple *E. coli* contamination test strips that has detection limit for several hundred *E. coli* contaminations per 100 ml water sample. The aim of this study was to examine the applicability of the quick and simple *E. coli* testing technique to make tailor-made locally affordable water quality information for non-specialist Two experimental field works were conducted by Community

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Development program, and environmental community service program conducted in Indonesia.

II. Materials and Methods

A. *Escherichia coli* Check Kit

Coliform bacteria test strip SC-N06 (Sankori, Japan) was used (Figure 1). The test strip utilizes two different assays, simultaneously. Coliform bacteria, generally stated as total coliform, is gram-negative bacillus that generate B-galactosidase (B-GAL). Total coliform is tested by B-GAL and 5-bromo 4 chloro 3 indolyl B-D galacto pyranoside (XG) based on colorimetric assay. Existence of a coliform bacteria on a test strip produce B-GAL, and the XG, which does not have color, is broken down by B-GAL into Bromochloro indigo that has blue color. Next, amongst coliform bacteria, only *E. coli* has B-gluconidase (B-GLU) activation. The existence of *E. coli*, 4-Methylumbelliferyl-B-D(-)-glucuronide broken down by B-GLU into 4-umbelliferone that has bright fluorescence light for 360nm UV light.

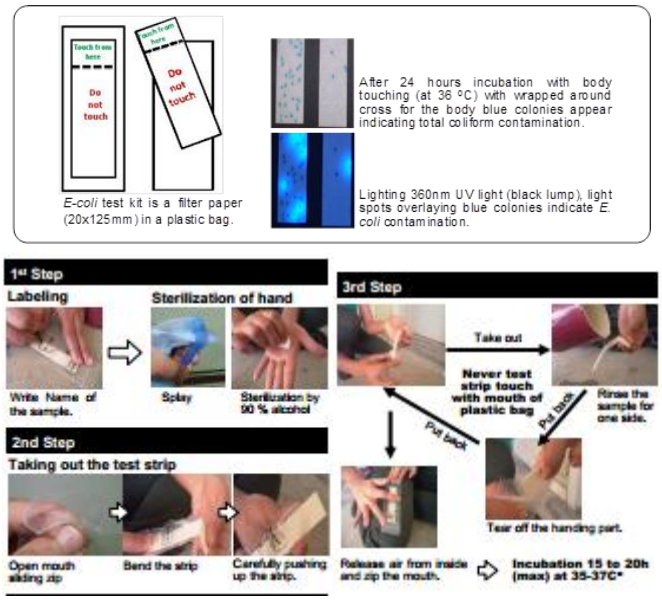

Fig.1. Water Sampling Procedure

B. *Escherichia coli* as Fecal Contamination Indicator

E. coli is now stated as the best indicator for fecal contamination [4]; [6]. Though, *E. coli* have been found without know sources of fecal contaminations in tropical area [7]; [8]. In the nutrient-rich tropics, *E. coli* is a member of the natural micro flora [9]. The reason is discussed with the similarity between the mammalian host environment and tropical ecosystem as the conductive *E. coli* growth in environment is a warm constant temperature, as well as high concentrations of free amino acids and sugars [10]. Thus, it is not totally confident that *E. coli* contamination is being the best indicator for fecal contamination in particular environment under tropical climate [4]. However in the first place, grossly *E. coli* contaminated water is a major source of exposure to fecal contamination and diarrheal pathogens. Secondly, *E. coli* contamination in tropical non mammalian host environments, that have high concentration of free amino acids, sugars concentration, and constant warm water temperatures are also indicate the inappropriate quality water resource for drinking and source of daily water consumption for household. Hence even more researches are needed for *E. coli* ecology in no host environment under tropical climate [15], it was assumed *E. coli* still be the best indicator for fecal contamination assessment in water source even in tropical area

C. Research Location and Water Source

Neighborhood association 15, Dempok Hamlet was engaged for experimental community development program, where is part of the village Gampingan (Dempok). The other program was performed with a public high school (SMA Negri 2 Madiun) in Caruban, where is a small town, the capital of the Madiun District. Based on the data reported disease prominent in the work area Gampingan village in 2012, diarrhea is the third highest disease after the Common Cold with this number of cases 136 cases or 2.3% [11]. In Madiun district, diarrhea morbidity by 2010 was 20.93 per 1000 population [12]. The number seems small, but it is only the tip of the iceberg of total number. During these fieldwork, E. coli contamination for diverse of local people's daily water sources were checked.

The water sources are dug wells, piped water which flowed from springs and stream in the mountains, and derived water relay tank in the village, from the tank, the water supplied to homes through pipes installed by the Village. Faucet water, the water is meant at research site in Dempok is the water that flows from the spring and stream via pipes then accommodated into households. Faucet water in Madiun research site was governmental tap water. In the village, the pipe water supply has been started since 2000, and it has more wide-spread this year since April of 2013 by village development program (government activity). Besides, there are people who directly utilize water from well to the reservoir in both areas.

Public bath, as a general custom of the regional society, is built, where water from faucet kept in bath-tub is generally used for bathing and washing crosses in daily life. Thereby people prepare water tank made in cement in their home, and the water kept in it is use for shower. For the each of households, most local people prepare water tank in their kitchen, called *gentong* made of plastic or clay, and use it to daily life. Differently from these daily water resources, natural springs water are also used, namely *Punden* , that is common daily water source in the village.

D. Community Development and Empowerment Program

The student activity in In accordance with the theme of community development in Dempok was hosted by management of Posdaya Based Mosque in the community.

The theme of University's community development program, which can be shared among Islamic Universities, was imitation of the historical development of Islam brought by the Prophet Muhammad; he started the activities of knowledge and development of the community mosque. Whereas, the activity was not only about religious education only instance where the Qur'an (TPQ) alone, moreover the activities include education, economic, entrepreneurship, and environment. By the context, students become agents of change. This activity is expected to be an initial step in the process to increase the public awareness for potential resources of the community which potentially improved or developed.

Fig.2. Typical water source in the village. 1: Pipe water from faucet that water provided through local piping system without chlorination, 2,3: Water reservoir at a household, 4: relay tank in the local pipe water system, 5: water in reservoir basin for washing use, 6,7: the source of river stream flow (punden: spring), 8: well, 9: river water, 10 : water at paddy field, 11: Bathroom with toilet, 13,14: water tank in kitchen, 15 : boiled water kept in basin. 1-8 in Dempok, 9-15 in Madiun.

III. Result And Discussion

A. Water Contamination

In Dempok area, all samples (24 samples out of 24 samples, with 4 missing value) were contaminated by E. coli, in which, 18 samples showed moderate level risk level (Moe et al. 1991) of E. coli CFU (colony forming unit, 2<CFU<10 /ml) for diarrhea. No samples was eligible (<0 CFU /ml) for direct drinking regarding any drinking water guideline. In Madiun area investigators visited three households and, checked E. coli contamination for local people's daily water source. Governmental faucet water in household 1 did not have contamination for total coliforms nether E. coli. For the household, even E. coli contamination was less after the water kept in clean conciliate water tank in bathroom. However E. coli contamination was moderate level (2<CFU<10 /ml) for faucet water if ground-water was the source in household 2 and 3, so as in such households, water kept in tank at kitchen also generally has moderate level (2<CFU<10) E. coli contamination. Even one sample from water tank at kitchen of household 3 showed significant risk level for E. coli contamination (CFU>10 /ml). Water sample from small stream near household and river showed significant E. coli contamination level. According to local people, the small stream and rivers are commonly used to take a crap by local peoples. In short, sample governmental faucet water was eligible for direct drinking, even that was kept in well managed water tank, regarding guideline for E. coli contamination. Though, if well water is used as the source of the faucet water, generally daily water was moderately contaminated by E. coli. In addition, E. coli contamination was also significant if the management of water tank is worse, even boiled water is kept in.

More than 1000 E. coli CFU per 100 ml, which is 10>CFU on a test strip, had significantly higher rates of diarrheal disease for children's drinking water [13]. Comparing with the criteria, our results from two research sites were lower than the significant risk revel. Whereas, what was consequence was more than half samples were moderately contaminated by E. coli (2-100 E. coli CFU per 100 ml). Moreover, all the water sources, such as, wells, and water distributed through pipe system were not eligible for drinking by E. coli contamination level regarding any water quality regulations and guidelines [4]. The base line data showed the general E. coli contamination in daily consumption of water in two experimental research sites.

Hereby an important research outcome extrapolated was the fact that the local community is geologically, ecologically, and socially just common state in East Java. It is mostly indicating general E. coli contamination in daily consumed environmental water in East Java.

B. E. coli test strip as quick and simply method for local tailor made information

From this activity, it was not only showed bacterial contamination of E. coli, but there were common harmonic relationship it seems the harmony between the students and the community in the implementation of the activity study i.e. active communication with the public when starting this study is also an attractive side in Community Development and Empowerment Program.

The concept to apply the easy and simple method also supports the term of community development program

namely, provide services, empowerment, and professional development with the application of science, technology, and art through information services, education and training, mentoring, assistance expertise, consulting, and resist action. Familiarity with the community was is a proof of attainment of the concept of the community development program.

TABLE I

RESULT OF TOTAL COLIFORM AND *E. COLI* CONTAMINATION FOR DAILY WATER SOURCES IN EAST JAVA, INDONESIA

Malang, East Java, Indonesia

Sample name	Total coliform	E. coli
Location	no reprecation	no reprecation
Water from faucet 1	14	2
Water from faucet 2	6	5
Water from faucet 3	11	1
Water from faucet 4	?	g
Water from faucet 5	12	g
Water kept in a basin 1	26	2
Water kept in a basin 2	6	4
Water kept in a basin 3	10	3
Water kept in a basin 4	6	2
Water kept in a basin 5	2	2
Water kept in a basin 6	5	2,g
Water kept in a basin 7	2	6
Water kept in a basin 8	10	5
Water kept in a basin 9	3	4
Well water 1	?	1
Well water 2	?	1
Well water 3	21	5
Well water 4	11	2
Well water 5	?	2
Well water 6	23	5
Water in relay-tank for pipedwater 1	5	2
Water in relay-tank for pipedwater 2	14	2
Water in relay-tank for pipedwater 3	3	4
Water in relay tank 1	13	b-g
Water in relay tank 2	17	
Water in relay tank 3	1	1
Public spring water 1	13	6
Public spring water 2	?	2

Madiun, East Java, Indonesia

Sample name		Total coliform			E. coli		
Location	Sample	1st	2nd	3rd	1st	2nd	3rd
Household 2							
Bathroom	Water from faucet	0	0	0	0	0	0
Bathroom	Water in basin for washing chlothes	0	1	1	0	0	1
Bathroom	Water pooled in a toilet	120	104	-	9	2	-
Household 1							
Bathroom	Water from faucet	11	8	-	2	2	-
Bathroom	Water kept in tank in a bathroom	43	52	35	9	8	6
kitchen	Water tank	19	18	5	1	(full)	5
kitchen	Water tank	49	34	35	5	5	5
kitchen	Boild water	29	29	25	2	5	5
kitchen	Water after washed dish	106	39	29	full	full	full
Bathroom	Water pooled in a toilet	22	40	50	full	full	full
Household 3							
Bathroom	Water from faucet	18	19	-	4	4	-
Bathroom	Water kept in tank	21	20	-	4	5	-
kitchen	Water after washed dish	28	31	-	1	4	-
kitchen	Watertank	33	32	-	12	10	-
kitchen	Boild water kept in a basin	4	3	-	0	0	-
outside	Well water near the house	24	32	-	9	6	-
Environmental							
outside	Water in swimming pool	0	0	0	0	0	0
outside	water in rice paddy field	48	11	56	9	6	14
outside	water of small stream near houses	72	124	53	full	full	full
outside	Natural river water	108	78	116	full	full	full
outside	Cow facis mix AQUA water	165	128	126	full	full	full

g: gren color, b-g: full bleu-green color. Green color indicates injoured E. coli cell contaminated.

Without using laboratory equipment, the test bacterial contamination of E. coli in water sources in the village Dempok and Madiun were successfully performed for local people's daily water sources by non-specialist students in and the communities.

C. Prospects and Development Program

In this research, two application works of E. coli test strip in a community development and Empowered program showed a model approach to test E. coli contamination in people's daily water source in community development program. One of the significant perspective here is that the program such was performed in Dempok is annual program of Universitus Islam Negeri Malang, and also other many Universities in Indonesia. Hence, it can be said that our approach shown in this paper has potential to implement to these activities having potential to be one of the major program. On the other hand, cooperation with teachers' network for environmental activity also has another potential as shown in the activity in Senior High School 2, Madiun in this study.

Based on the case studies above, applicability of E. coli test strip made sense of significance in a University's community development programs, so that the next step is to fabricate a device that possible to be provided to such programs. Based on fieldwork by this research, a device is designed as shown in Fig. 3, which was "flyer with E. coli test strip" taking analogy with prior study [14]. The device is consisted with E. coli test strips, a flayer, and 2 ml alcohol in microbus. These all packed in a plastic bag. The flyer contain ex-planation about importance for E. Coli testing, manual to use E. Coli test strip, water quality criteria to interpret the result.

Fig. 3 a potential device design; manual, alcohol in micro tube, *E. coli* test strip are packed in plastic bag.

IV. CONCLUSION

Local people's daily water source has generally moderate

risk level (2 <CFU <10 /ml) for *E. coli* contamination due to the source is shallow groundwater and river water for daily life. Thereby, chlorination for swimming water pool, boiling of water for drinking show significant effect for pasteurization. These results are appropriate from daily sense. The importance of this research is the fact that the reliable results could survey by non-specialist using quick-and-simple *E. coli* test strip via two trial Community Development and Empowerment Programs. During the field survey, University students used the *E. coli* test strip, and the test kit was easy-to-use, and also fun to use. For the fieldwork in Madiun, incubator in University laboratory is used, on the other hand, body touch incubation was applied for the fieldwork in Dempok. Consequently it was examined that application of the easy-to-use *E. coli* test strip could provide the capacity for *E. coli* contamination checking in Community Development and Empowerment Program without any special equipment. By this research, a significant capacity for *E. coli* contamination testing technique to make tailor-made locally affordable water quality information for non-specialist was successfully shown. Strictly to say, the reliability of this result is required to be tested by comparison with laboratory based standard method. The research has planned to be performed in this year. Toward the next step, a potential device was designed to implement affordable *E. coli* testing capacity in Community Development and Empowerment Programs.

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Ms. Mutmainah not only active in her institutional learning, but also trying to develop her experience with became a volunteer in The Institute of Research and Community Outreach, active supporter of ProFauna Indonesia. Beside gather in Writing Club such as Forum Linkar Pena (FLP) and Proyek Nulis Buku Bareng (PNBB), she also works as freelance writer, columnist and citizen reporter. As her dream to be an icon of muslimah researcher who inspired lots of student in Indonesia, she was recorded as the best college student who has a lot of achievements. She achieved an award as The Best New College Student in OSFAK FSAINTEK 2011 and wanna be an outstanding college student majoring science FSAINTEK UIN 2015.