COMPARATIVE STUDY OF WASTEWATER KNOWLEDGE TOWARDS SUSTAINABLE INFRASTRUCTURE: A CASE STUDY OF GERMANY AND INDONESIAN UNIVERSITY STUDENTS

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Abstract. Knowledge is transferred in order to run specific goals. Sustainable wastewater infrastructure plays a significant role to the human needs especially the demand for clean and safe water. People's knowledge will also influence the process of treating water to be discharged to water bodies that support the sustainable wastewater infrastructure in Germany and Indonesia. The focus respondents in this research are the university students in Germany and Indonesia who are considered to have a capability to gain and implement specific knowledge. Survey was conducted to indicate how well the university students know about the wastewater knowledge, the knowledge transfer occurrence, and the correlation of some variables such as study background, degree program, and nationality of the university students with wastewater knowledge and knowledge transfer occurrence to support the sustainable wastewater systems and infrastructures in Germany and Indonesia. The wastewater knowledge of university students in Germany and Indonesia is still low and the correlation of some variables such as study background, degree program, and nationality of the University students with wastewater knowledge and knowledge transfer occurrence are still considered low.

Keywords: Knowledge management, knowledge transfer, sustainable development, wastewater infrastructure

I. INTRODUCTION

Sustainable infrastructure development is commonly correlated with many various aspects, such as social, economics and politics. Sustainable can be defined as a long-lasting process, while infrastructure represents a system that supports human's life with the surrounding environment, makes everything works in harmony and boosts the value of each structure that is facilitated. In other words, sustainable infrastructure is a platform or a system that supports human's life with the surrounding environment that will occasionally be used through different generations which are not easily destroyed.

One of the sustainable infrastructures that has been continuously developing is the wastewater infrastructure. By emphasizing the wastewater word, we are expected to be able to represent it by explaining how the wastewater is collected, treated, discharged and reused. Unfortunately, the development of wastewater infrastructure is not well-facilitated evenly in all countries.

The differences of each country's income and population, technology development, weathers, human resources, regulations, and locations can be the barriers for several countries to achieve the sustainable wastewater infrastructure. Indonesia is included in the country that still has to work hard to implement the sustainable wastewater system. As reported in the articles about Indonesia's wastewater infrastructure, the systems of collecting, treating, discharging and reusing wastewater are not really well-maintained. Low priority on wastewater management, inadequate drainage and sewerage system, low funding to develop the sewerage system, lack of modern technology and experts are the reasons the development of the wastewater infrastructure must be prioritized immediately.

This inadequate system of the wastewater leads to many discrepancies in Indonesia. The wastewater can be poisonous if not well-treated. It will create the increment of the mortality rate of people suffer from several diseases. The common system for the wastewater management in Indonesia is the on-site system. The on-site system is implemented in the surrounding area of where the wastewater is produced. The on-site system is supported by the availability of the septic tanks.

However, only 12 cities have some form of wastewater networks, such as Balikpapan, Banjarmasin, Bandung, Batam, Cirebon, Jakarta, Medan, Prapat, Surakarta, Tangerang, Yogyakarta, and Denpasar. These networks reach about 2% of urban residents in each location. Even though over 70% of urban households have the on-site system, most of the septic tanks do not function properly (Development Alternatives Inc. for the United States Agency for International Development, 2006). When the untreated wastewater is discharged, people will find it difficult to get safe water because it is already contaminated. Therefore, the untreated wastewater gives bad impact in the social, environment, and economics sections.

Meanwhile, Germany as one of the leading innovators in the technology development has treated their wastewater in an adequate way. Germany has put the wastewater treatment in a high priority, they have invested the funding to be used in the wastewater treatment program, developed the wastewater treatment technology with the following fair amount of the technology experts. 96% of the people in Germany have a connection to the public sewerage system (Seeger, 1999).

However, without any knowledge about wastewater, the sustainable wastewater infrastructure will not be able to be implemented. Knowledge about the sustainable wastewater infrastructure is needed to achieve the goals in the perspective view of economic, social and environment issues. Not only the modern technology needed to treat wastewater in the wastewater treatment plant to support the sustainable wastewater infrastructure but also the knowledge of how it is treated in order to be the safe treated wastewater that will be transferred back to water bodies or to the lakes and rivers. Even though the treatment of wastewater is the municipality responsibility, the users also play an important role of using water and producing wastewater. As the population increases over years, the demand for water also increases, it leads to the case of used water should be treated from contaminating the drinking or clean water.

People sometimes will not think of where the water they used will be transported after, or how it is treated. Recent facts also gathered that untreated wastewater is harmful to every living organism, especially when it contaminated the clean water or drinking water. For this matter, the user's knowledge should also be improved to support the existence of sustainable wastewater system and infrastructure especially wastewater from domestic use/residential/households. This research aims to analyze and compare how well the knowledge transfer towards sustainable wastewater infrastructure occurs in Germany and Indonesia. However, the objective to be identified in this article is to analyze and compare the wastewater knowledge in Germany and Indonesia towards the sustainable wastewater infrastructure.

II. LITERATURE REVIEW

Knowledge, also known as an information that belongs to individuals' mind, is a personalized information related to facts, procedures, concepts, interpretations, ideas, observations, and judgments (Alavi & Leidner, 2001). The information may or may not be new, unique, useful, or accurate. Others have described knowledge terminology as "a state or fact of knowing" that the knowing is a circumstance of understanding which is gathered through experience or study. Knowledge can also be defined as the sum or range that has been identified, discovered, or learned (Schubert, Lincke, & Schmid, 1998) as cited by (Alavi & Leidner, 2001).

Knowledge has the capability to influence future action (Carlsson, El Sawy, Eriksson, & Raven, 1996) as cited by (Alavi & Leidner, 2001). It is capable not only for specific action, but also has the capacity to take and use information, learning and experience results; and determine which information is essential for the purpose of decision making (Watson, 1999) as cited by (Alavi & Leidner, 2001).

Explicit and tacit knowledge are the two main views of knowledge. Tacit knowledge is defined as the knowledge that depends largely on experiences. This type of knowledge is dependent and personal because sometimes it is really hard to communicate and should be implemented through action, commitment, and involvement (Nonaka & Takeuchi, 1995). Tacit knowledge is considered to be the most valuable source of knowledge and will lead to the important development in an organization (Wellman, 2009). Tacit knowledge can be found in human mind and it is hard to capture and codify (Nonaka & Takeuchi, 1995).

Tacit knowledge is involved in the minds of human stakeholders, namely cultural beliefs, values, attitudes, mental models, expertise, capabilities, and skills (Botha, Kourie, & Snyman, 2014). Tacit knowledge can occur between direct communication between people including in the meetings, face-to-face discussion, mentoring (exhibitions, seminars, conferences), teaching, lecturing, due to sharing the precious knowledge about the definition or how something is done that only owned by particular people or experts.

Another form of knowledge is the explicit knowledge that can be known as the formalized or codified knowledge that can be found in documents, newspapers, books, articles, written documents on the Internet and other written and printed media, thus a large number of participants/recipients could access this knowledge. Explicit knowledge is the knowledge that explains about the definition of particular thing so that people can enrich their knowledge about a particular thing (Brown & Duguid, 1998). This explicit knowledge is expected to be easy to identify, store and retrieve (Wellman, 2009), due to its form that can be stored, reviewed and updated.

Knowledge transfer contains the focused and purposeful communication from a sender to a known

receiver (King, 2006a), it implies a clear objective and is unidirectional (King, 2006b), as cited by (Wiewiora, 2011), however, sharing is less-focused in the distribution, to people who are often anonymous to the sender (King, 2006b). Paulin & Suneson (2012) as cited by Andreasian & Andreasian (2013) defined knowledge transfer as the form of focused and unidirectional communication of knowledge amongst individuals, groups, or organizations and these recipients can apply the knowledge, or have the ability to apply the knowledge, or have a cognitive understanding.

Knowledge transfer can be understood by processing knowledge from the giver to the receiver through a recreation process (El Sawy, 1998) as cited by (Alavi & Leidner, 2001). Not only the process of transferring the element of the receiver's capacity to process the knowledge is also considered (Vance & Eynon, 1998) as cited by (Alavi & Leidner, 2001). From the five majority elements of conceptualized knowledge transfer, transfer channels are also to be focused on. Knowledge transfer networks can be informal or formal and personal or impersonal (Holtham & Courtney, 1998) as cited by (Alavi & Leidner, 2001). There are some effective ways to promote socialization such as unscheduled meetings, however the dissemination may not be wide (Holtham & Courtney, 1998) as cited by (Alavi & Leidner, 2001) and those are considered as the informal mechanisms.

Wastewater consists of domestic wastewater (from households/residences), industrial wastewater, storm/rain water, extraneous water (leakages from rainwater, groundwater, and spring water) and agricultural water. In a residence, wastewater is generated by toilets, sinks, dishwasher sinks, showers, bathtubs, and clothes washers (National Environmental Services Center, 2011). In terms of domestic wastewater, it also consists of two types including greywater and Blackwater. Greywater is wastewater without urine, feces, and water for flushing that means it includes water from kitchens, showers, sinks, and washing machines. That conclude Blackwater consists of urine, feces, and water for flushing (National Environmental Services Center, 2011). Untreated wastewater will become a problem for all the living organisms when clean water is contaminated by it. When we ensure that water is clean, we can prevent some diseases and deaths caused by contaminated water. Wastewater and sludge disposal are basic requirements to increase the health of the society and development of communities and societies. As the population increases the amount of clean water needed increases as well as the production of wastewater.

Those indicators lead to the idea of keeping the sustainable wastewater system and infrastructure to process the wastewater to be used and stored back to water bodies as treated wastewater. The inappropriate of sewer and wastewater infrastructure can also affect the cleanness of drinking water, it will cause diseases such as cholera and other diseases that periodically killed tens of thousands of people in major cities (Martland, 2012). Therefore, a careful wastewater treatment and sanitation is needed to secure the clean water or water resource for the future generation.

Treating and disposing of wastewater is also a key issue in global sustainability because of the amount of waste produced on a daily basis and the health and environmental implications of not dealing with it (Werner, 2009). For the public users, the role that they can give is by not flushing or disposing of cigarettes, wet wipes, facial tissue, cooking oils, coffee filters, medicines, painting oils, leftovers, pads or tampons into the toilet or sink and placed into the waste bins instead (Stadtentwässerungsbetriebe Köln AöR.).

As stated in Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of Germany 2013, Germany is considered as the European country with the highest wastewater reprocessing and recycling rate. In the total of more than 96% wastewater from private households or public facilities is discharged into wastewater treatment plants and sewage treatment plants. Wastewater management in Indonesia has been considered to be the responsibility of the municipal government. A household or private sector in case of the on-site domestic wastewater treatment and domestic wastewater has a septic tank, other than that wastewater in Indonesia is treated in septage treatment plant and wastewater treatment plants (off-site treatment) for only 12 cities, such as, Balikpapan, Banjarmasin, Bandung, Batam, Cirebon, Jakarta, Medan, Prapat, Surakarta, Tangerang, Yogyakarta, and Denpasar.

To sum up, in this research knowledge management specifically knowledge transfer that will be measured is between the municipal, creators, experts, companies, education institutions as the source of knowledge to transfer the knowledge to the public especially university students to use, learn and implement in term of wastewater, greywater, and blackwater categorization.

III. RESEARCH METHODOLOGY

In this research, finding facts about the concept, questions or attributes, collecting factual evidence and studying the relationship between these evidences in order to test a particular theory or hypothesis are the circumstances the quantitative research is chosen. The approaches to the data collection also consist of two data collections, there are primary data and secondary data collections.

Surveys are chosen because of the limited time frame the researcher has to complete the research. Surveys are also able to collect data from a relatively large number of respondents within a limited period (Naoum, 2007). The results from the survey approach will be generalized and abstracted from a particular sample or population.

The purpose of this questionnaire is to identify and measure the knowledge of the public users towards wastewater to support the sustainable wastewater infrastructure. The respondents are chosen to be the

university students/higher institutional students in each country and in the amount of 259 students for Germany students and 659 Indonesian students. The questions in the questionnaire are formatted in open-ended questions and closed-ended questions. The function of the first part of general respondent information will be to indicate whether the background of the study, their household condition and the duration of stay in particular area will influence the knowledge transfer of sustainable wastewater infrastructure.

The second part of the questionnaire is made to identify how well the student knows about the knowledge of wastewater. The third part of the questionnaire is intended to identify whether they have ever experienced any discomfort because of their habit towards the wastewater system. The last part will the identification of is the knowledge transfer occurs between the users and the municipal or even the awareness that has been built by the government. Mann-Whitney Test or U-test will be used to compare the difference between the mean scores of two samples in both countries, Indonesia and Germany. The data results from students who are studying in Germany and Indonesia will be assessed and compared especially for the part 2 of the questionnaire that will be explained in this article.

To conduct the comparison test, we need to formulate the hypothesis of the formulation that consists of H0 and H1. The level of confidence that will be used is 5% (0.05). To prove the hypothesis, the U table will be used, however, there are 659 data for students in Indonesia and 259 students in Germany after the questionnaire survey was conducted. Therefore, the hypothesis will be based on Z-score/the normal distribution (Sheskin, 2000).

Due to the consideration of 5% of the level of confidence, this research is aimed to determine which data is higher than another data. As the one-tailed test is used the value of z-critical will be 1.65. The H0 will be rejected if the value of z-calculation is lower than the z-critical, otherwise, the equal or greater value of z-calculation will result in the acceptance of alternative hypothesis H1. P-value will also be calculated to measure the significance to reject the null hypothesis. Sample 1 will always be the sample that has a higher sum of data and sample 2 has a lower sum of data. r_1 and r_2 are determined after the sorting process of data gathered and it will be ranked from the lowest to the highest.

IV. RESULTS

The score will be determined by giving 10 points for each correct option chosen by the respondents and no points will be given to every wrong option chosen by the respondents. Table 1 shows that 79 university students in Germany (31%) were able to answer the categorization of wastewater (domestic wastewater), while Indonesia had 91 university students (14%) who answered correctly. 23 and 61 university students in Germany and Indonesia had no opinions about the categorization of wastewater.

Table 1. Wastewater knowledge score

Answer point	Germany		Indonesia	
	Total	%	Total	%
0	23	9	61	9
10	21	8	98	15
20	22	8	91	14
30	29	11	143	22
40	52	20	129	20
50	33	13	46	7
60	79	31	91	14
Total	259	100	659	100

Based on Table 2, there are 73 and 87 respondents (28% and 13%) of university students in Germany and Indonesia who answered correctly about the greywater categorization. 139 and 385 respondents (54% and 58%) of university students in Germany and Indonesia had no opinions about the greywater categorization.

Table 2. Greywater knowledge score

Answer point	Germany		Indonesia	
	Total	%	Total	%
0	139	54	385	58
10	21	8	116	18
20	26	10	71	11
30	73	28	87	13
Total	259	100	659	100

Based on Table 3, there are 41 and 151 respondents (16% and 23%) of university students in Germany and Indonesia who answered correctly about the categorization of blackwater. 123 and 315 respondents (48% and 48%) of university students in Germany and Indonesia had no opinions about the categorization of Blackwater.

Table 3. Blackwater knowledge score

Answer point	Germany		Indonesia	
	Total	%	Total	%
0	123	48	315	48
10	22	8	98	15
20	73	28	95	14
30	41	16	151	23
Total	259	100	659	100

The comparison analysis for students in Germany and Indonesia are intended to measure which have higher wastewater knowledge. The null hypothesis and alternative hypothesis will be:

H0= Indonesia has equal or lower knowledge of wastewater than in Germany

H1= Indonesia has a higher knowledge of wastewater than in Germany.

Table 4. The comparison result of the wastewater knowledge in Germany and Indonesia

No	Wastewater knowledge	Z-Score	P-Value	Z-Critical	Level of confidence	Conclusion
1	Wastewater	-6.83	4.15×10^{-12}	1.65	0.05	Reject Null Hypothesis
2	Greywater	-5.32	4.95×10^{-8}	1.65	0.05	Reject Null Hypothesis
3	Blackwater	-2.77	0.0028	1.65	0.05	Reject Null Hypothesis

From Table 4., it can be seen that university students in Indonesia has a higher knowledge of wastewater than in Germany based on the rank, median score, and the number of respondents. The knowledge of wastewater itself includes the categorization of wastewater, greywater, and blackwater. The Z-score for wastewater, greywater, and blackwater have higher Z-Score than the Z-critical and lower P-value than the level of confidence.

V. DISCUSSION

The knowledge about wastewater, greywater, and blackwater are given in the form of multiple choices that multiple answers can be chosen. The correct answer for the wastewater categorization especially in domestic wastewater categorization is the used water from taps; showers or bathtubs and washing machine, water for flushing, urine, and feces (National Environmental Services Center, 2011). The method used to do the identification of the correct answer is the researcher will mark 10 points for each correct option that was chosen by the respondents and there is no point given for every wrong option chosen by the respondents, however, there will be no minus calculation given for every wrong option chosen by the respondents both in Germany and Indonesia.

There are 79 students in Germany that answered correctly about the wastewater (domestic wastewater) categorization, meanwhile, in Indonesia, there are 91 students. Moreover, there are some students in Germany and Indonesia that have no identification to know about the wastewater, 23 students in Germany and 61 students in Indonesia to be precise.

The second question is about the greywater categorization which has 3 correct types, such as the used water from taps; showers/bathtubs and washing machine (National Environmental Services Center, 2011). 73 students in Germany are correct about answering the categorization of grey water, in contrast, there are 87 students in Indonesia who answered correctly. There are 139 students in Germany who had no opinions about greywater, while there are 385 students in Indonesia.

The third question is about blackwater categorization which consists of water for flushing, urine, and feces (National Environmental Services Center, 2011). 41 students in Germany answered correctly and 151 students in Indonesia answered the correct options for blackwater categorization. The number of students who had no opinions about blackwater is 123 and 315 in Germany and Indonesia respectively.

From the scoring of the corrected answers, we can see that the percentage of students in Germany who were able to answer correctly about wastewater, greywater, and blackwater is 31%, 28%, and 16%. To compare, there are still 14% of students in Indonesia who answered correctly about the wastewater and 13% for greywater categorization and 23% who had correctly answered the blackwater categorization.

In other words, the students' knowledge about wastewater, greywater, and blackwater in both countries are still limited but the comparison using Mann-Whitney test between which students in both countries who have a higher knowledge of wastewater, greywater, and blackwater are identified in Indonesia as it is simply indicated by the higher number of respondents in Indonesia.

VI. CONCLUSION

The fundamental knowledge about wastewater, such as how students are able to indicate the categorization of domestic wastewater, greywater, and blackwater towards the sustainable wastewater infrastructure contributed by the users especially focusing for the university students in this research. The results reveal that the knowledge of university students on wastewater, greywater, and blackwater categorization is still low in both countries.

The Government of Indonesia should be able to provide accessible documents for the public users especially for university students to read or look up, always develop, and improve the wastewater infrastructure. Other than that, raising the public awareness of not flushing or disposing anything into the toilet and sink should always be conducted. The recommendation for university students is to start implementing what they have learned or gained from wastewater knowledge through reliable sources such as the government booklets, brochures, or guidelines. By gaining the wastewater knowledge, it is expected for the university students to know what wastewater is, consists of, and other things correlated to treating wastewater such as not flushing or disposing of things other than urine, feces and toilet paper (for several countries).

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly, 25*(1), 30.

Andreasian, G., & Andreasian, M. (2013). *Knowledge Sharing and Knowledge Transfer Barriers. A Case Study.* (Master), Linnaeus University, Sweden.

Botha, A., Kourie, D., & Snyman, R. (2014). *Coping with Continuous Change in the Business Environment, Knowledge Management and Knowledge Management Technology*. Elsevier.

Brown, J. S., & Duguid, P. (1998). Organizing Knowledge *California Management Review, 40*(3), 90 - 111.

Carlsson, S. A., El Sawy, O. A., Eriksson, I., & Raven, A. (1996). *Gaining Competitive Advantage Through Shared Knowledge Creation: In Search of a New Design Theory for Strategic lnformation Systems*. Paper presented at the Proceedings of the Fourth European Conference on lnformation Systems, Lisbon Portugal.

Development Alternatives Inc. for the United States Agency for International Development. (2006). *Comparative Study Centralized Wastewater Treatment Plants in Indonesia*. Retrieved from http://pdf.usaid.gov/pdf_docs/Pnadl920.pdf

El Sawy, A., Eriksson, I., Carlsson, S. A., and Raven, A. (1998). Understanding the Nature of Shared Knowledge Creation Spaces Around Business Processes: An International Investigation.

Holtham, C., & Courtney, N. (1998). The Executive Learning Ladder: A Knowledge Creation Process Grounded in the Strategic Information Systems Domain. *Proceedings of the Fourth Americas Conference on lnformation Systems*, 594-597.

King, W. (2006a). Knowledge Sharing. *The Encyclopedia of Knowledge Management*, 493-498.

King, W. (2006b). Knowledge Transfer. *The Encyclopedia of Knowledge Management*, 538-543.

Martland, C. D. (2012). *Toward More Sustainable Infrastructure: Project Evaluation for Planners and Engineers*. United States of America: John Wiley & Sons, Inc.

Naoum, D. S. G. (2007). *Dissertation Research and Writing for Construction Students* (second ed.). Oxford, UK: Elsevier Ltd.

National Environmental Services Center. (2011). *A Drop of Knowledge: The Non-Operators Guide to Wastewater Systems*. Retrieved from Washington DC: www.nesc.wvu.edu

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company; How Japanese Companies Create the Dynamics of Innovation* New York, NY: Oxford University Press.

Paulin, D., & Suneson, K. (2012). Knowledge Transfer, Knowledge Sharing, and Knowledge Barriers - Three Blurry Terms in KM. *The Electric Journal of Knowledge Management, 10*(1), 81-91.

Schubert, P., Lincke, D., & Schmid, B. (1998). A Global Knowledge Medium as a Virtual Community: The Net Academy Concept. *Proceedings of the Fourth Americas Conference on Information Systems*, 618-620.

Seeger, H. (1999). The History of German Waste Water Treatment. *European Water Management, 2*(5), 6.

Sheskin, D. J. (2000). *Handbook of Parametric and Nonparametric Statistical Procedures; Second Edition* (2 ed.). The United States of America: Chapman & Hall/CRC.

Stadtentwässerungsbetriebe Köln AöR. 10 gute Ratschläge zum richtigen Umgang mit Abwasser! In R. A. a. S. K. Wasserforum Köln, AöR. (Ed.). Köln, Germany: StEB Köln.

Vance, D., & Eynon, J. (1998). On the Requirements of Knowledge-Transfer Using IS: A Schema Whereby Such Transfer is Enhanced *in Proceedings of the Fourth Americas Conference on Information Systems*, 632-634.

Wellman, J. L. (2009). *Organizational Learning: How Companies and Institutions Manage and Apply Knowledge* Palgrave Macmillian.

Werner, M. (2009). *Water and Wastewater Systems Sustainability in Remote Australia*. (Master of Engineering Master), University of Wollongong, Australia.

Wiewiora, A. (2011). *The role of Organisational Culture, Trust and Mechanisms in Inter-Project Knowledge Sharing* (Doctor of Philosophy), Queensland University of Technology, Australia.