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APPLICATION OF THE JAPANESE JOHKASOU DECENTRALISED SEWAGE WASTEWATER SYSTEM IN EGYPT

M. A. Zaki Ewiss*, Zakia A. M. Ahmed*, A. M. El Gendy*, A. M. Mahmoud*, Hala M. F. El Miniawy*, A. Osman*, M. H. Hussein*, A. M. Khattab*, Y. Kamimoto**, M. Takeuchi**, T. Hasegawa**

**Cairo University (Arab Republic of Egypt)*

***Nagoya University (Japan)*

On-site sewage wastewater poses a challenging problem in Egypt and the other Arab countries. It requires a balance of appropriate levels of technology and the operational complexity necessary to obtain high-quality effluent together with adequate reliability and simplicity to accommodate infrequent maintenance and monitoring. In this report, the on-site Japanese' Johkasou wastewater treatment technologies is considered as a promising solution for water purification in Egypt. The on-site Johkasou bioreactor was installed at Cairo University to study its applicability and advantages of highly purified sewage water. This system was successfully operated and maintained. Results on the environmental and health effects of sewage wastewater before and after treatment on cultivating some crops and safe rearing of rabbits and broilers are presented and discussed.

***Keywords**: Johkasou, sewage, broiler, rabbit, crops.*

ПРИМЕНЕНИЕ В ЕГИПТЕ ЯПОНСКИХ ДЕЦЕНТРАЛИЗОВАННЫХ СИСТЕМ JOHKASOU ДЛЯ ОЧИСТКИ СТОЧНЫХ ВОД

М. А. Заки Евис*, Закиа А. М. Ахмед*, А. М. Эль Женди*, А. М. Махмуд*, Хала М. Ф. Эль Миньяви*, А. Осман*, М. Х. Хуссейн*, А. М. Хаттаб*, И. Камимото**, М. Такеучи**, Т. Хасегава**

**Каирский университет (Арабская Республика Египет)*

***Нагойский университет (Япония)*

Очистка канализационных сточных вод представляет собой сложную задачу для Египта и ряда других арабских стран. Это требует баланса соответствующего уровня технологий и операционных сложностей, необходимых для получения высокого качества сточной воды, наряду с надежностью, простотой размещения и возможностью мониторинга систем. В настоящем статье рассматривается применение японской системы Johkasou для очистки сточных вод как метод перспективного решения для очистки воды в Египте. Биореактор Johkasou был установлен в Каирском университете для изучения его применения и преимущества высокой степени очистки сточных вод. Эта система успешно эксплуатируется и обслуживается. Результаты исследований демонстрируют влияние качества сточных вод на окружающую среду до и после обработки, а также на выращивание некоторых культур и безопасного разведения кроликов и бройлеров.

***Ключевые слова:** Johkasou, канализация, бройлер, кролик, культуры.*

INTRODUCTION

Treatment of domestic wastewater in Egypt mostly utilizes septic tanks, but these have low water purification capability, with effluent density at around 200 mg of Biological Oxygen Demand (BOD)/L. In addition, maintenance such as sludge extraction is rarely done, meaning that systems often do not operate at their full purification capability. This has become a problem in water conservation. Also, the pollution load from domestic wastewater is influenced less by black water than by gray water, which septic tanks do not treat, and this is also an issue for water conservation [1].

Meanwhile, Japan's combined treatment Johkasou have excellent water quality purification capability (less than 20 mg BOD/L), and they treat both black water and gray water, making them effective in water conservation. In addition, they are able to reduce CH_4 emissions to levels far below those of septic tanks (about 75 percent reduction in terms of compared CH_4 emission coefficients). Also, Japan in recent years has begun to see the increasing popularity of low-carbon Johkasou that cut energetic origin CO_2 by about half.

In Japan, the most important feature of the decentralized wastewater treatment (DWWT) is the choice of technology. Johkasou system, which was first introduced to help building water flush toilets in areas without sewage pipelines, represents the current DWWT technology in Japan. Johkasou system was also the main technological approach by which the Japanese government developed the single household, and small scale wastewater treatment program started at the end of 20th century. Subsidies provided by the Japanese government greatly relieved financial burden of local governments and residents for construction and operation of the treatment facilities [2]. It has been mentioned that this subsidy policy became the most important factor for the promotion of this technology. From the year 2001, Japanese government started to reform the cabinet. The office of Johkasou affairs was shifted from the Ministry of Health Labor and Welfare to the Ministry of Environment. This shift indicated that the Johkasou system will serve not just as a technology of wastewater treatment, but also an important management approach to improve the nation-wide water environment. The Japanese method, in which the role and function of the central government was emphasized, has the potential to be applied in Egypt considering its current top-down management system. However, this single technology approach does not fit completely the situation of country. The first reason is the diversity of natural conditions wastewater treatment technologies are very sensitive to climate and geographical factors, so a single or small number of technological options could not meet the demand for areas with different features. The other reason is the constraint on economical levels.

The development of Johkasou technology in Japan is discussed in detail in Ref.'s [1–23]. First, Johkasou is the Japanese word for on-site wastewater treatment; it is a combination of the words ***johka***, which means purification, and ***sou***, meaning tank or tub. Johkasou are mainly used in two situations: (1) when there is no access to sewers and (2) in high population density areas for on-site wastewater treatment including water reclamation. Up until World War II, Japan was largely a rice-based agricultural society [2]. At that time the most common form of waste treatment was vault toilets (pit latrines), with the night soil collected for use as agricultural fertilizers and soil conditioners. Following World War II, flush toilets were rapidly introduced throughout Japan. As Japan became increasingly industrialised, the population shifted to urban areas and sanitation became a problem due to population density. The transition from vault toilets (pit latrines) to Johkasou originated to facilitate the introduction of flush toilets. Since then, sewers and Johkasou have developed side by side. As of the year 2000, 71 % of household wastewater in Japan was receiving some type of treatment and 91 % of Japanese residents had flush toilets [3]. The Johkasou Law mandates johkasou for new construction in areas without sewers. Johkasou are different from European septic tanks – even the smallest units (5–10 population equivalents (p.e.)) undergo an aerobic process, where high water quality for non-potable reuse in Japan is obtained [4].

Since last century until now, the Egyptian villages and rural areas did not receive the same level of government attention of sanitary services. As a result, coverage of urban sanitation was only 56 % and rural coverage of villages 4 % until as late as 2004. The government pledged to raise the ratio of villages connected to the centralized sanitation networks to 11 % and managed to reach 13 % coverage by 2010 (603 villages from a total of 4670). Notwithstanding the emphasis on mismatch between water service and sanitary service connection coverage that various human development reports emphasize, a more serious mismatch exists between water production and the capacity to collect and treat wastewater. Currently, water distribution networks stretch over 146,000 km vs. only 39,000 km for sanitation networks and only two-thirds of water produced is collected (16 million m^3/day of 24 million m^3/day) and only (10 million m^3/day) is treated. This means that the most important challenge is to collect all wastewater produced through the centralized networks or other mechanisms, and to be able to build necessary wastewater treatment plants. Ideally secondary treatment is required, but the objective must be at least to secure primary treatment for all wastewater currently produced. Otherwise, pressure will continue to build up on existing collection and treatment facilities and households' resorting to informal methods of discharging of wastewater will continue to pollute water resources and the environment [1]. Consequently, this badly conditions of sewage water effects the health of people, producing unsafe animals and fish proteins as well as cultivating inedible crops.

For these reasons, it is believed that the Japanese's Johkasou system as a decentralised compact and highly efficient onsite wastewater treatment facility can be considered as an adequate technology for use in individual households or small communities in Egypt and other Arab countries. The application of this on-site system was successfully adapted previously in China, Vietnam, and Myanmar and many other countries. This biological system is located mostly in villages and rural areas, where there is no access to a sewerage system. It can treat both black water (wastewater from toilets) and gray water (non-fecal wastewater from kitchen, bathroom, etc.) to achieve high effluent quality of less than 20 mg/l biochemical oxygen demand (BOD).

On the basis of the above mentioned discussion, Cairo University has suggested the "Johkasou" as a successful on-site Japanese technology for purification of the sewerage water in Egypt and the other Arab countries.

Experiment one

Installation of on-site Johkasou decentralised Treatment System at Cairo University

Since 2010, both Cairo and Nagoya Universities, have cooperated in a strategic project aimed to localizing Johkasou system (as Packaged Onsite Aerated Wastewater Treatment Plant or PAWTP) in Egypt. In this regards, Nagoya University donated a Johkasou tank, (model CE10, Fuji Clean) to be installed at the Center of Inter(multi)disciplinary Studies at Cairo University. Where, a large scientific group from the faculties of Science, Agriculture and Veterinary Medicine cooperated to support: (1) the installation, the technical operation and the working conditions of the on-site system in the Egyptian environment. (2) the investigation into the effect of using the sewage water before and after treatment for improving the life conditions, e.g. cultivating crops and producing safe animals and fish proteins.

The objectives of this research are as follows:

• Technology development and technology transfer,

• Scientific and technical training,

• Lowering the economic cost of localization of this technology,

• Getting rid of sewage in an environmentally safe method,

• Use of treated water in agriculture and producing safe animal and fish proteins,

• Minimization of infectious diseases transmitted by sewage contamination,

• Dissemination of Johkasou System in Egypt, Arab and African countries.

Needs assessments: Sewage wastewater pollution in some villages in Giza governorate

To understand the need assessment of the project under study and to point out the environmental problem of Sewage Wastewater pollution in Egypt, the research team visited some villages in Giza province and interviewed the local people. Below are some Pictures that show the effect of using sewage polluted water on life. This problem remains unsolved (see Fig. 1*a*–*h*).

Purification Test of the Treated Wate

The operation and maintenance of Johkasou onsite decentralized system (Model CE 10, Fuji Clean) was successfully demonstrated. In Table 1, results of the water analyses parameters of the influent, and effluent of the installed Johkasou plant in comparison with the tab water (analysed at the National Research Center, Giza, Egypt) are presented. It is noticed that the value of both BOD and COD (chemical oxygen demand) in the effluent is removed by the factor of 96 %.

Experiment two

Studies of the effect of sewage wastewater before and after treatment on the production of rabbits and chicken protein and in use for agriculture

In the following, the effects of Sewage pollution on the production of rabbits and chicken protein as well as in fish farming and in use for agriculture (farm vegetable crops) are presented. Experimental evaluation of the sewage and treated water on the rearing of different animal species including rabbits, and broiler chicken was performed. In addition, the meat quality of the reared animal is presented.

A) Pathological studies on the effects of sewage and treated water on rabbits health Scientific background:

Rabbit production plays a considerable role in solving the problem of meat shortage in Egypt, particularly on the level of the small-scale farmers and new reclaimed areas. However, the most obvious limitation to rabbit production in hot climate area is the susceptibility of this species to heat stress and availability of clean healthy and good quality drinking water, which lead to the impairment of production and feed efficiency. In addition, the cost of buying clean drinking water in rabbit farms can affect the feasibility of rabbit production.

Objective: The aim of this work was to investigate the efficiency of sewage water with different Biochemical Oxygen Demand (BOD) levels on rabbit's health from a pathological aspect in comparison with treated and tap water.

Material and methods: Biological evaluation was applied on 50 male native rabbit which were divided into five groups. The animal groups provided with 100 % untreated water, 70 % untreated water, 30 % untreated water, treated water which have differed BOD level and tape water as control standard group. Five animals from each group were sacrificed after 30 days and the remaining animal were sacrificed at the end of the experiment after 45 day. Blood samples were collected for serum biochemical parameters evaluation. Tissue specimens from different organs were collected for the histopathological examination.

Results: The weight gain and mortality rate were recorded during the experimental period. We noticed a decrease in the weight gain in animal groups which drink from 100 % untreated water and 70 % untreated water in comparison with animals drink on treated and tap water.

Fig.1:
a) sewage water polluting canal; b) Sewage water polluting the River Nile; c) Local sewage drainage in house; d) Sewer in house; e) Caws drinking from sewage; f) Using Sewage water in irrigation; g) The use of sewage water in fish farms; h) Dead Fish in sewage polluted canal

Table 1

Parameters of water analyses of the influent, effluent and tap water

Parameter	*Unit*	*Sample 1 Row Water*	*Sample 2 Treated Water*	*Percent Removal*	*Sample 3 Drinking tap Water*
pH		7,2	7,3		7,3
Total Suspended Solids	mg/l	88	N.D	100	N.D
Total Nitrogen	mg/l	7,28		84,9	N.D
Ammonia	mgN/l	0,84	N.D	100	N.D
Nitrate (NO_3-N)	mg/l	0,4		25	0.3
Nitrite (NO_2-N)	mg/l	0,01	N.D	100	N.D
Total Phosphate	mg/l	1,7	N.D	100	N.D
Chemical Oxygen Demand	mgO_2/l	254	10	96,1	7
Biological Oxygen Demand	mgO_2/l	140	5,5	96	2,1
Total Bacterial Count (22 °C)	CFU/ml	–	–	–	2
Total Bacterial Count (37 °C)	CFU/ml	–	–	–	3
Total Caliform	MPN-index/100 mL	1,5x106	2,1x103	99,9	N.D
Faecal Coliform	MPN-index/100 mL	7,0x104	7,0x102	99,9	N.D
Total Stri Cocci	MPN-index/100 mL	–	–	__	N.D

Liver function tests showed significant decrease in ALT level in 70 %, 30 % and treated groups. The largest decrease was observed in the treated group than the 30 % and 70 %, respectively when compared with the control one. The highest increase in ALT level was in the 100 % treated group when compared with the control one. On other side, AST significantly decreased in all treated groups. The result of the total protein level showed significant difference between all treated groups. There was a significant decrease in 0 %, 30 % and 70 % treated groups and no significant difference between 70 % and 30 % groups "while it significantly increased in 100 %" treated group when compared with the control group.

Kidney function tests showed a significant increase in Creatinine and Urea level in the 100 % treated group when compared with the control group. The 70 %, 30 %, 0 % treated groups showed no significant difference in comparison with the control group. The Uric acid level showed a significant increase in the 100% treated group. 30 % and 0 % treated groups showed a significant decrease in Uric acid level and no significant difference was observed in the 70 % treated group when compared with control group.

Histopathological findings were focusing on the main lesions of liver, kidneys and urinary bladder. The progressive lesions were noted in 100 % and 70% untreated water. The **hepatic parenchyma** showed degenerative changes characterized by granularity and vacuolation of cytoplasm with condensation of nuclear chromatin. Focal aggregation of mononuclear cells mainly lymphocytes and macrophages scattered all over the hepatic lobules were also seen. The **renal** parenchyma showed degeneration of tubular epithelial lining with intra-tubular albumius casts. The renal cortex revealed leukocytic infiltration mainly lymphocytes and macrophages in-between necrotic renal tubules. The **urinary bladder** mucosa showed vacuolar degeneration of its epithelial lining with atrophy of urinary bladder folds.

On the other hand, treated and tap water give the same picture. Hepatic lobules showed normal histological structure and appeared as regular hepatic cords with central vein. The hepatocytes sometimes showed mild swelling with granularity of its cytoplasm. **"Kidney"** showed normal histological structure of nephrons including renal tubules and glomeular tufts. The renal medulla revealed uniform tubular structure without any renal casts. The urinary bladder mucosa displayed intact epithelial lining with uniform urinary folds. As a c**onclusion:** the experiment described above aimed at examining the effect of the quality of treated sewage water using Johkasou on breeding of rabbits. The animal rearing on treated or tap water revealed good general body condition which reflected on animal performance in contrast to animals rearing on sewage water (Zaki Ewiss, project final report, Cairo University 2016).

B) Impact of contaminated water used in poultry farms on poultry meat production

The current study was conducting to investigate the impact of using contaminated water under field conditions to rear broiler chickens on their survival and production, and the socioeconomic assessment of broiler meat produced with contaminated water on human health.

Field water samples were collected from different broiler farms and subjected to chemical and microbial examination. An experiment was designed to study the effect of contaminated water with different levels of BOD on bird performance including live body weight, somatic indices, mortality, morbidity, and immune response.

The results revealed that, water used in commercial broiler farms have pH values ranging between 6,4–8,9, a pH of less than 8,0 was recorded in 8/13 samples. Ammonia 0,01–2,5mg/L, total hardness between 160–480 mg/L, Chloride between 96–340 mg/L, and Phosphate 1–4mg/L. 1-Microbial investigation represented by the estimation of total colony count ranged between 36x103 and

158x105 CFU/100ml, and total Coliform count ranged between 2- ≥1600 MPN/100ml and fecal Coliform were detected from 2 out (using underground water) of 13 samples. The experiment for rearing broiler chickens with water has high and low BOD concentration (20 and 9 ppm) showed higher pH, sulphate, phosphate and T. Coliform count which decreased live body weight and somatic indices of edible (liver, and spleen) and immune organs (thymus and bursa fabricus). It worth to mentioning that, water used for meat producing poultry under field conditions has improper water quality with higher levels of chemical and microbial parameters (used underground water) affecting final live body weight. The higher level of BOD in experimental water with two levels of BOD induced lower LBW somatic indices of edible, immune organs potentiate disease risk affection for birds, and socioeconomic impact of produced meat (Zaki Ewiss, project final report, Cairo University 2016).

C) Effect of sewage water before and after treatment on broiler health

Another experiment was conducted to investigate the impact of using untreated compared to treated sewage water in rearing broiler chickens on their health and production indices. The water samples were subjected to chemical and bacterial analysis. 131-day old broiler chicks were assigned into five groups each group was given a different water mixture, compromising of sewage water with drinking water dilutions of 30, 70, and 100 % treated sewage water, and tap water. Food and water intakes were recorded daily and weekly. Blood samples were collected weekly for evaluation of bird response to field vaccines (NDV). Some organs and tissue samples were collected twice on day 21 and 42 days to identify the histopathological changes associated with the of use of sewage and treated water. The highest T. Coliform count (50->1600MPN) and BOD value (37,1–42,4) were obtained from non-treated sewage water (NTSW 100 %). In the 4th and 5th week samples old the sewage water SW 100 % induced the lowest feed intake (1364,29±70,44 and 1851,43±176,77, respectively) versus other groups. The reduction percentage of the current chemical oxygen demand (COD) values between treated sewage water TSW and non-treated (100 %) was 93,07 %, for BOD was 94,74 %, ammonia concentration was 66,66 %, nitrite was 99,5 %, and nitrate was 90 %. The treated SW showed higher feed intake (FI) at week 2 versus NTSW groups (9 kg Vs 5 kg) as well at the 4th week (13 kg Vs 12 kg). On the 5th week (end of rearing period) all groups attained the same feed intake (19,5 kg). All groups achieved recommended food conversion rate, FCR (less than 2). Control group (Treated water) and 70 % sewage water had a little more than normal food/water ratio (2,07 and 2,1, respectively). Sewage water (30 %) and treated sewage water induced similar high water / feed ratio (2,8). Rearing broiler chickens with sewage water either raw (100 %) or diluted with tap water (70 and 30 %) decreased antibodies titer post NDV vaccination at 7, 13, and 27 days old Versus treated SW and TW. The deaths were recorded on the 13th day of the experiment due to stress associated vaccination, hot weather and deprivation of water especially in the groups with 70 and 100 % sewage water. The postmortem examination of the dead chickens revealed the presence of typical gout picture reported as precipitation of chalky white material on pericardium, serosal surface of liver, muscle and kidneys with great swelling of the latter. Euthanized birds drinking sewage water revealed the presence of necrobiotic changes in the renal tubules of the kidneys and in the liver in addition to different types of enteritis. The lymphoid organs showed different degrees of lymphocytic depletion with reticular cells hyperplasia. As a conclusion, wastewater used for rearing broiler chickens badly affected bird health and diseases response manifested by decreased humeral immune response to NDV vaccine associated by impaired lymphoid organs (lymphatic depletion). Decreased performance indices (increased FCR = 2, associated with necrotic changes in liver and kidney which impaired bird vitality and physiological functioning, (Zaki Ewiss, project final report, Cairo University 2016).

D) Effect of sewage water before and after treatment on meat quality

The objectives for the present study were to demonstrate the effect of water contaminated with different concentrations of sewage (30, 70 and 100 %) and the water treated together with the tap water by using low cost systems on the quality of broilers and rabbits reared on that water. The aerobic plate count (APC) and Coliforms of the meat obtained from chicken reared on sewage water at different concentrations (30, 70 and 100 %) were higher than standard levels. However, the APC and Coliforms of meat obtained from chickens reared on treated sewage water were within the permissible limit. The pH values of all meat samples obtained from all groups were within the normal accepted values. Meat samples obtained from young chicken reared on sewage water at concentration of 100 % revealed lower flavor scores than the acceptable scores (3,5). The overall acceptability scores were lower than the acceptable level. The meat sample of this group showed a darker color than the other groups. Moreover, Meat samples obtained from old chicken reared on sewage water at concentrations of 70 and 100 % revealed flavor scores lower than the acceptable scores (3,5) with overall acceptability scores of these samples lower than the acceptable level, for more detail see (Zaki Ewiss, project final report, Cairo University 2016).

E) Bacteriological, parasitological and pathological studies on sewage: pollution of fish aquacultures in some localities in Egypt

In this experiment, the effect of the sewage pollution in some fish aquacultures at Faiyum, Port Saied, and Dakahlia provinces was investigated. Water and fish samples (*Oreochromis niloticus)* were collected from aquacultures of such localities. Bacteriological examination and chemical parameters of water samples revealed contamination of water with Coliforms and many bacterial species of significant importance to human health. Total Colony ount (TCC) of water in rearing fish pond of two farms at Faiyum province was 56×104 CFU/mL and 67×104 CFU/mL. The Coliform count was 450 MPN/mL and 520 MPN/mL, respectively. The Faecal Coliform was isolated from both farms. In Port Saied Province, TCC in the water sample of the examined farm was 12×103 CFU/mL, Coliform count was 210 MPN/mL and the Faecal Coliform was also recorded. Examination of fish samples and tissue specimens indicated contamination of fish with some bacterial isolates of human health significance. Streptococcus Sp., Staphylococcus Sp., and Salmonella were recorded in both fish and water samples of all examined localities. Two bacterial isolates of public health importance (*Mrganella morganii* and *Pseudomonas cepacia*) were identified. The parasitological examination revealed detection of encysted metacercariae (EMC) of Diplostomatidae, Prostomatidae, and Heterophyid in skeletal muscles. The histopathological examination revealed mild tissue reaction in case of bacterial infection and severe pathological lesions in different organs in case of EMC infection. Lamellar hyperplasia and mononuclear cells infiltration of gill tissue was a common finding. In skeletal muscles, atrophy of muscle fibres, myolysis, and myophagia were detected. Other examined organs showed pathological changes of variable degrees. Myxosporidia was recorded in the tissue of some examined fish while an external gill protozoon was noticed in others. The results, varying values in the amount of chemical components in plant tissues were observed concluded that water supply of fish aquacultures in examined localities was contaminated with sewage and treatment system is required, for more detail see (Zaki Ewiss, project final report, Cairo University 2016).

F) Effect of treated and untreated sewage water on some vegetable crops.

In this part of the project, the experiment was carried out in the green house at the Botany Department, Faculty of Agriculture, Cairo University, during the period from April to October 2015 using raw sewage and treated water obtained from the on-site Japanese Johkasou system installed at Cairo University This study aimed to distinguish the effect of irrigation by sewage and treated water on the different morphological characters and chemical constituents of some edible vegetable crops. These crops were; Cucumber (*Cucumber sativus L.*), Pea (*Pisum sativam* L.), Parsley (*Apium petroselinum* L.), Roquette (*Eruca sativa* Mill.), and Molokia (*Chorcorous olitorious*). Data revealed that all the plants of these crops irrigated with sewage water represented the greatest values for all the growth and yield characters and Outweigh those irrigated with the treated water. While analyzing the dry weight of the plant irrigated with the previous treatment, representing different chemical values in plant tissues. The data also indicated that the amount of heavy metals in the tissues of these plants irrigated by sewage water was for remarkably high, for more details see the project progress report (Zaki Ewiss, 2015).

CONCLUSION

Satisfying wastewater treatment needs through on-site treatment requires a multifaceted approach, incorporating technologies ranging from separate waste collection to membrane bioreactors. The feasibility and appropriate implementation of treatment varies greatly depending on location. It is apparent that many Johkasou treatment methods need to be upgraded to ensure adequate protection of the Egyptian environment. However, Japanese Johkasou which is based on membrane technologies allow for very high-quality effluent to be used as reclaimed water. The unique history of on-site wastewater treatment in Japan illustrates the many factors that must be taken into consideration when determining suitable technologies for Egypt and the other Arab countries. In any location, assurance that a maintenance plan will be implemented is critical to the long-term success of all technologies. Other important factors include cost, footprint, desired level of treatment, availability of water, and opportunities for beneficial reuse. Advances need to continue being made in on-site treatment processes to provide more reliable systems, allowing for high-quality effluent and biosolids that can be considered safe for reuse applications, while at the same time being affordable and simple to maintain.

From Cairo University's experience, it is concluded that small-scale Johkasou can be easily installed on a household level and treat the discharge wastewater locally. These have remarkable advantages compared to sewerage systems from the perspective of protecting the local aquatic environment and improving the cost-benefit performance. The advantages of localizing Johkasou technologies in Egypt are summarised as follows:

• **Low initial investment cost.** As small-scale Johkasou are mass-produced, the price of Johkasou can be maintained at a level for individual or household users. A Johkasou can be installed in a small, unused space and procedures or costs, such as for the acquisition of land for installation.

• **Little topographic limitation**, short installation time and early realization of the effects. As a small-scale Johkasou can be installed in a small, spare space the equivalent of a parking spot and the device's inflow pipes are short, there are few topographic limitations when it comes to the installation of small-scale Johkasou. It takes only a week for a typical installation. Moreover, when the Johkasou begins functioning, its effect on wastewater treatment will be evident immediately.

• **Invaluable contribution** to maintaining sufficient water in small rivers and aquatic environments near inhabited areas. As the effluent of Johkasou is discharged on-site to surrounding small rivers through drainpipes, it contributes to maintaining sufficient amounts of water in small rivers, enhancing water circulation in local areas and does not damage the natural scenery.

• **Johkasou-treated water and sludge are easy to reuse.** As Johkasou are basically designed to treat domestic wastewater from individual houses, there are few toxic substances in Johkasou-treated water and sludge. This makes it possible to reuse these for various purposes.

• **Less vulnerable to earthquakes and other disasters** When earthquakes or other disasters strike, a Johkasou can be functioning again very soon because it has neither a complicated piping system nor enormous mechanical apparatus. Water in Johkasou may be utilized for various purposes depending on the degree of electric power and water supply recovered.

The effect of using the untreated sewage wastewater in cultivating crops and rearing rabbits and poultry showed several vital diseases. These diseases may affect the public health. The purified effluent of Johkasou plant at Cairo University was implemented successfully in producing safe animal proteins and reusage in agriculture.

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