DIGITALIZATION OF WATER VENDING MACHINES

Rostyslav Mudryk[1], *Yevhen Orestov*[1]

[1]National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine, 03056, rostyslav.mudryk@gmail.com

DOI: https://doi.org/10.20535/2218-930032023302842

Vending, the sale of goods and services through automated systems, has gained worldwide popularity as a convenient and low-maintenance method of commerce or service delivery. With its wide range of applications, vending can be used in almost all areas of commercial and social life. This article is dedicated to studying the impact of digitalization on the operation of water vending machines. These machines represent a modern way of obtaining safe and physiologically complete drinking water. Their advantage lies in autonomous operation without the constant presence of servicing personnel. This is achieved by replacing filters and maintenance tasks carried out on a time-based logic basis. However, time-based logic does not account for actual volumes of purified water, leading to over expenditure on servicing some machines and untimely maintenance, resulting in a deterioration of water quality for others. This study investigates the impact of digitalization on optimizing service costs and the cost price of water purification. It is shown that through digitalization, the maintenance logic was changed to volume-based, resulting in reduced expenses on replacement filters (51%), servicing (13%), and collection (17%). Collectively, these factors reduced the cost of water by 20%. The decrease in cost enhances the profitability of the vending machine network. With a fixed water price, this is the only way to increase profitability and attract investors, consequently popularizing water vending machines. Subsequent research will focus on seeking alternative filters, materials, and water preparation technologies to achieve even greater machine autonomy. By assessing the established impact of digitalization on water vending machine operations, a predictive cost of water is calculated, assuming compliance with all operational requirements. The predicted cost reduction amounts to 39%, providing economic justification for future research endeavors.

Keywords: *drinking water, cost, Internet of Things, optimization, reverse osmosis, water treatment technologies*

Received: 3 January 2024 Revised: 1 February 2024 Accepted: 20 February 2024

1. Introduction

Access to safe and physiologically complete drinking water is a pressing task for humanity. Collective systems for water preparation and vending, such as water vending machines (WVMs), represent a promising solution to this task (Moommala et al., 2021). Among the advantages of this solution are water safety, accessibility to a lot of people, and the lowest price (Falcone et al., 2023). However, disadvantages include non-compliance of water composition with the requirements of physiological completeness, insufficient autonomy due to frequent replacement of consumables and servicing, low profitability due to water price limitations, and high cost (Kita et al., 2020; Picardal et al., 2018; Yongyod, 2018). Finding rational ways to address the shortcomings in the operation of existing WVMs is both relevant and necessary for their widespread adoption (ระวาดชั et al., 2012). One of the ways to reduce the frequency of WVM servicing and the number of consumables is digitalization. Therefore, studying the impact of digitalization on the operation of WVMs is important, and the results of such studies can be used to optimize their operation.

Literature Review and Problem Statement

Article (Mudryk & Mitchenko, 2023) formulates requirements for the operation of machines and compares the actual performance indicators of WVMs with these requirements. Non-compliance with requirements regarding water quality concerning pH, hardness, and dry residue; productivity; and servicing frequency is demonstrated (Christian Di Carlo, 2022). Solutions for optimizing operation are proposed, including the digitalization of WVMs and the replacement of servicing logic from time-based to volume based.

The implementation of digitalization will allow changing the servicing logic of the machines from time-based to volume based. Such a change is necessary since the volume of dispensed water in the WVM network varies from 50 to 1000 dm^3/day (Mudryk & Mitchenko, 2023). Time-based servicing logic leads to overconsumption of consumables and too frequent servicing for one group of machines and untimely replacements and servicing for another group. Therefore, transitioning to volume-based servicing logic optimizes WVM operation.

Optimizing WVM operation through digitalization will lead to a decrease in the cost of water (Grievson et al., 2022). The cost structure of water in WVMs under time-based servicing logic is consists of: replacement filters (34%), rental (24%), depreciations (19%), servicing (12%), cash collection (6%), utility payments (5%).

Changing the servicing logic will affect expenses related to replacement filters, servicing, and collections. The cumulative contribution of these expense categories to the total cost is 52%. Therefore, optimizing them will have the most significant effect.

The digitalization of water vending machines involves equipping them with water flow meters, sensors for monitoring the equipment status, and payment modules. This will enable gathering information about the actual performance of each machine. Additionally, in the digital management system of the machines, the resource lifespan of each replaceable filter needs to be specified. Based on the actual water consumption, the system can forecast the date for their replacement. Consequently, servicing each unit will be scheduled precisely when the filter resources are nearly depleted, while the machine continues to dispense water with specified quality and productivity parameters.

Furthermore, in the digital system, it is necessary to set the maximum capacity of cash and coin boxes. This will allow estimating the date for the next collection based on the accumulated volume of bills and/or coins, the maximum capacity of the boxes, and the average daily intake of bills and coins.

This approach will achieve maximum prolonged operation of the machine without constant personnel supervision, optimal frequency of filter replacements and collections, thereby reducing the cost of water preparation. Therefore, it is advisable to assess the impact of digitalization on the number of replaceable filters, technical servicing, collections, and the cost of prepared water.

Objective and Research Tasks

The objective of this study is to determine the impact of digitalization on reducing the cost price of water in water vending machines. To achieve this objective, the following tasks need to be accomplished: determine the influence of digitalization on the number of replaceable filters; determine the influence of digitalization on the frequency of servicing; determine the influence of digitalization on the frequency of collections; evaluate the cumulative impact of digitalization on reducing the cost of water purification.

2. Materials and Methods

For the study, a network of WVMs (Vseredyni Akvaboksu Chystoi Vody | BWT Aqua (Inside the Aqua Box of Pure Water | BWT Aqua), n.d.) consisting of 71 units installed and operational in Kyiv, Ukraine, was selected. The distribution of machines in the network based on the volume of dispensed water is illustrated in Figure 1.

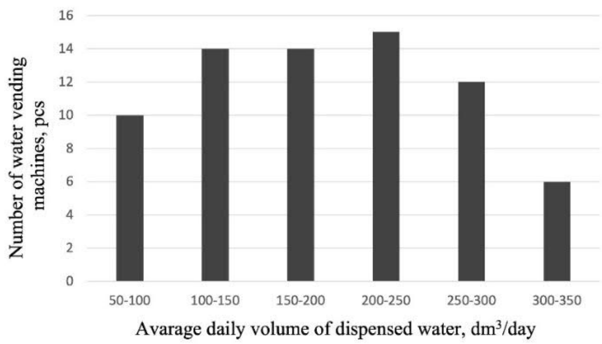

Fig. 1. *Distribution of machines in the network by the volume of dispensed water*

Figure 2 presents a schematic diagram of a water vending machine with elements of digitalization.

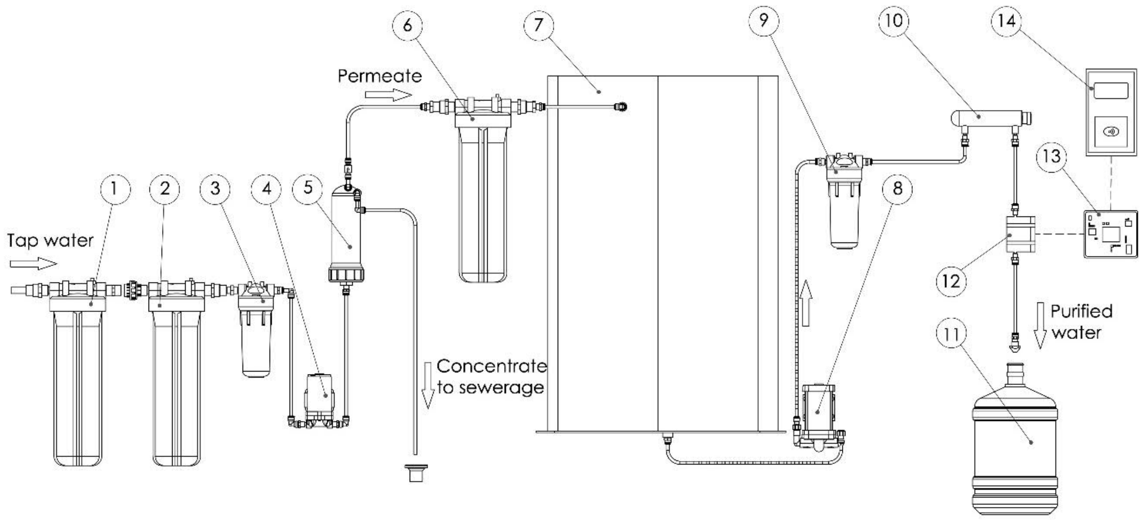

Fig. 2. *Schematic diagram of a water vending machine*

1 - Mechanical purification filter; 2 - Activated carbon filter for chlorine removal; 3 - Antiscalant dosing cartridge; 4 - High-pressure pump; 5 - Reverse osmosis module; 6 - Mineral filter; 7 - Open type pure water tank; 8 - Water dispensing pump; 9 - Activated carbon filter for improving organoleptic quality indicators of water; 10 - Ultraviolet disinfection unit with an incandescent lamp; 11 - User bottle; 12 - Electronic flow meter; 13 - Controller; 14 - Payment module.

It is important to note that some filters are installed along the feed line of the raw water, namely filters 1, 2, 3, while filters 5, 6, and 9 are on the line supplying already purified water to the user. The reverse osmosis module has a certain hydraulic efficiency coefficient (HEC), which is the ratio of purified water volume to raw water volume (Tyvonenko et al., 2023), flow meter 12 is installed on the line of purified water.

Therefore, the placement of filters should be considered when calculating the frequency of their replacement. Specifically, the frequency of replacing filters installed before the reverse osmosis module should be increased by the value of the reverse osmosis module's HEC.

Servicing the machines involves periodic replacement of filter elements and collections. The list of filter elements and their annual quantity required for operation based on time-based replacement logic is provided in Table 1.

Based on the available metrological means of control in the technological scheme (Figure 2), as well as data processing tools and elements of the payment system for data collection and processing, a server infrastructure and software were created, as shown in Figure 3.

Table 1. *List of consumables and types of servicing based on time-based logic*

Consumable Materials		
Replaceable Filters	Quantity per Year	Capacity, dm^3
Mechanical Purification Filter	4	80 000[1]
Activated Carbon Filter	4	80 000[1]
Antiscalant Cartridge	4	40 000[1]
Reverse Osmosis Module	2	50 000
Mineral Filter	4	50 000
Activated Carbon Filter	4	40 000
Servicing		
Replacement of Consumable Materials	4	-
Collections	12	-

[1] When calculating the replacement frequency of filters, it is necessary to consider the Hydraulic Efficiency Coefficient of the membrane module, which is 50% for the selected machines [11].

The server software (SS) collects and processes data from vending machines, calculates statistical indicators of machine performance, and allows remote control of vending machines by sending commands and changing their settings. The SS is based on event-driven architecture (Cabane & Farias, 2024) and client-server architecture (Shakirat Oluwatosin, 2014) and ensures high data throughput from machines received asynchronously.

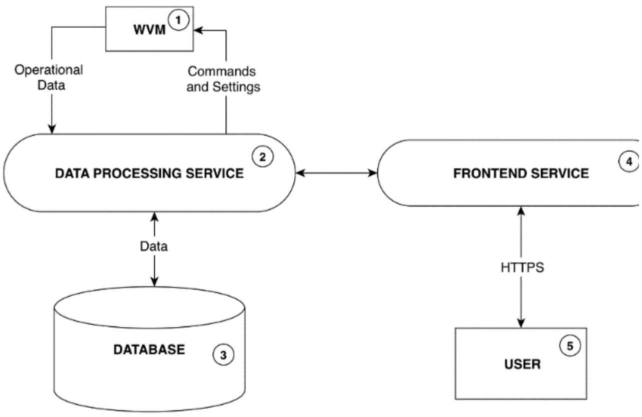

Fig. 3. *Structure of the server software*

The operation of the SS follows the following algorithm: The WVM (Figure 3, position 1) sends data to the server using a TCP and/or UDP-based protocol as transport (Eddy, 2022). The data from the vending machines are decoded and processed by the data processing service from the WVM controllers (Figure 3, position 2), after which they are stored in the database (Figure 3, position 3), from where they can be retrieved and viewed by various clients through the service's API (Figure 3, position 2) - for example, a web dashboard as a frontend service (Figure 3, position 4) or a mobile application.

Additionally, using the service (Figure 3, position 2), settings can be changed, or commands can be sent to the vending machine - such changes will be saved in its database and, when a connection is established with the vending machine controller, transmitted to it.

The embedded software of the WVM controller performs the following functions:

1. Control of the water purification equipment of the WVM.
2. Management of the payment process for dispensing water to consumers.
3. Monitoring the technical condition of the WVM - detecting faults, etc.
4. Recording information about all events in the operation of the WVM in the internal memory of the controller.

Data exchange with the SS on servers.

3. Results and Discussion

Impact of Digitalization on the Quantity of Replacement Filters

To determine the impact of transitioning from time-based servicing to volume-based servicing in the software, resources of replacement filters (In-Line Filters, n.d.) were specified in Table 2, along with the capacity of cash boxes for bills and coins.

The calculation of the quantity of replacement filters was carried out based on the actual volume of dispensed water. The quantity of service maintenance was determined based on the frequency of replacing each filter.

The quantity of cash collections was based on the actual amount of coins and bills. The impact of digitalization was determined by comparing the quantities of replacement filters, service maintenance, and cash collections per year using both time-based and volume-based logic for the entire sample of WVMs.

Table 2 shows that the transition from time-based filter replacement logic to volume-based logic leads to a reduction in the quantity of filters by 836 units per year or 51%. The decrease in the quantity of filters is observed for all groups of WVMs based on average daily fill volumes. However, the higher the fill volumes, the smaller the change in the quantity of filters.

Table 2. *Change in the quantity of filters for a sample of 71 WVMs with the application of digitalization*

Range of average daily fill, dm^3	**Quantity of replacement filters per year, pcs**		**Change in the quantity of filters**
	Time-based logic	**Volume-based logic**	
50-100	230	50	-78%
100-150	322	112	-65%
150-200	322	140	-57%
200-250	345	195	-43%
250-300	276	192	-30%
300-350	138	108	-22%
Total	1633	797	-51%

Impact of digitization on the quantity of service maintenance visits

An analysis of the results regarding the impact of digitization on the quantity of service maintenance visits is presented in Table 3, showing a reduction in the number of service maintenance visits for WVMs with an average daily fill ranging from 50 to 200 dm^3 by 25% to 63%. For WVMs with an average daily fill of 200 to 250 dm^3, the transition from time-based logic to volume-based logic does not affect the number of service maintenance visits. However, for WVMs with an average daily fill of 250 to 350 dm^3, there is an increase in the frequency of service maintenance visits when transitioning to volume-based logic.

Table 3. *Change in the quantity of service maintenance visits for a sample of 71 WVMs when digitization is applied*

Range of average daily fill, dm^3	**Quantity of replacement filters per year, pcs**		**Change in the quantity of filters**
	Time-based logic	**Volume-based logic**	
50-100	40	15	-63%
100-150	56	35	-38%
150-200	56	42	-25%
200-250	60	60	0%
250-300	48	60	+25%
300-350	24	36	+50%
Total	284	248	-13%

Impact of digitization on the quantity of cash collections

The results of comparing the number of cash collections per year using both time-based logic and digitization are presented in Table 4, indicating that for WVMs with a low average daily water fill, the number of cash collections is significantly lower when digitization is applied. For WVMs with an average daily fill above 300 dm^3, an increase in the number of cash collections is observed. The overall reduction in cash collections for the network is 141 collections or 17%.

Table 4. *Change in the quantity of cash collections for a sample of 71 WVMs when digitization is applied*

Range of average daily fill, dm^3	Quantity of replacement filters per year, pcs		Change in the quantity of filters
	Time-based logic	Volume-based logic	
50-100	120	51	-57 %
100-150	168	100	-40 %
150-200	168	156	-7,1 %
200-250	180	169	-6,1 %
250-300	144	143	-0,7 %
300-350	72	92	+27 %
Total	852	711	-17 %

Impact of digitization on the reduction of water purification cost

Table 5. *Change in the cost of purified water for a sample of 71 WVMs when digitization is applied*

	Time-based logic		**Volume based logic**		**Change**
Expense item	**Expenditure, thousand Euro/year**	**%**	**Expenditure, thousand Euro/year**	**%**	
Replacement filters	89	34%	44	21%	-51%
Rent of premises for WVM	62	24%	62	30%	0%
Depreciation of WVM	51	19%	51	24%	0%
Servicing	31	12%	27	13%	-13%
Cash collection	16	6%	13	6%	-17%
Utility payments	13	5%	13	6%	0%
Total	262	100%	210	100%	-20%

From Table 5, it follows that the implementation of volumetric servicing logic for WVMs leads to a reduction in the cost of purified water by 20%.

The cost reduction is due to decreased expenses on replaceable filters (51%), reduced frequency of cash collections (17%), and fewer service visits (13%).

The study on the impact of digitization on optimizing the cost of water purification in WVMs involved determining the influence of digitization on the following cost components:

1. Quantity of replaceable filters.
2. Number of service visits.
3. Frequency of cash collections.

Digitization allowed the utilization of volumetric tracking logic for filter replacement and service visits in WVMs, as well as the planning of cash collections based on actual funds accumulated in the WVMs, as opposed to simple time-based planning.

The implementation of digitization resulted in a 20% reduction in the cost of purified water in the WVM network with a mean daily water dispensing volume ranging from 50 to 350 dm^3 per day due to:

1. Decreased expenses on replaceable filters (51%).
2. Reduced expenses associated with service visits (13%).
3. Lower expenses related to cash collections (17%).

The decrease in expenses on replaceable filters is attributed to the prolonged filter lifespan after digitization, which can be explained as follows.

In the absence of digitization, the resource of replaceable filters is solely determined by their operational time (3 months for filters and 6 months for reverse osmosis membranes), without considering the actual volume of purified water produced and dispensed by the WVMs due to the lack of a measurement method for this volume. This leads to earlier replacement of filters in WVMs with low mean daily dispensing volumes, exceeding their nominal volume resource specified by filter characteristics, while in WVMs with high dispensing volumes, filters may significantly exceed their nominal volume resource within the allocated time frame.

This conclusion is supported by the noticeable trend in Table 3 towards a gradual convergence of the number of replaceable filters when using digitization to the number of filters under time-based logic as the mean daily dispensing volume of WVMs increases. Since the network's indicators are influenced by the number of WVMs in each group based on the mean daily dispensing volume, for the WVM network with mean daily dispensing volumes ranging from 50 to 350 dm^3, the overall decrease in the number of replaceable cartridges, and therefore, the reduction in expenses on replaceable cartridges, amounts to 51%.

The reduction in expenses on service visits is also attributed to the full utilization of the nominal volume resource of replaceable filters, the extension of their service life, and consequently, the decrease in the frequency of service specialist visits to the WVMs for filter replacement.

Since the number of service visits directly depends on the cartridge resource, it also depends on the mean daily dispensing volume of the WVMs, as evident in Table 4. Moreover, there is a significant discrepancy in the nominal volume resources among the replaceable filters in the water purification scheme of the WVMs. For instance, from Table 1, it can be observed that the anti-scale cartridge has the lowest resource of 40,000 liters, which is twice less than the resources of other replaceable filters. Thus, the need for replacement of this specific filter often becomes the main reason for service maintenance, resulting in a relatively low overall effect of digitization on the number of service visits compared to the effect of reducing the number of replaceable cartridges – the decrease in the number of service visits amounts to only 13% for the entire network.

Therefore, it can be assumed that a prospective direction for further reduction in the cost of purified water in the WVMs, as well as achieving the set goal of ensuring the normal operation duration of the machine for 12 months (Mudryk & Mitchenko, 2023) without operator intervention, is to explore alternative solutions regarding the choice of the anti-scale cartridge filter.

The reduction in expenses on cash collections due to the decrease in the number of collections is facilitated by the opportunity for more effective planning of collection visits based on data on actual funds accumulated in the WVMs compared to simple time-based planning, where WVMs are visited for cash collection once a month.

As evident from Table 5, the change in the number of cash collections also depends on the mean daily dispensing volume of the WVMs. This is explained by the fact that the price of water for the consumer in the WVM is fixed, and consequently, the more water the WVM dispenses each day, the faster money accumulates in it. Similar to the number of service visits, there is a noticeable increase in the number of cash collections compared to the time-based logic for WVMs with large mean daily dispensing volumes. Since WVMs with smaller mean daily dispensing volumes predominate in the network, the overall decrease in expenses on cash collections for the network amounts to 17%.

Due to the reduction in expenses on the components of water cost in the WVMs influenced by the implementation of digitization, the overall reduction in the cost amounts to 20%. Such a reduction in cost allows increasing the profitability of vending machines, which attracts investors and contributes to the proliferation of WVMs as a source of drinking water.

Additionally, the analysis of the results of digitization implementation allows making certain assumptions regarding further directions for improving WVMs to meet the requirements outlined in (Mudryk & Mitchenko, 2023).

For instance, as mentioned earlier, in order to reduce the frequency of service visits for each WVM to once every 12 months, it is necessary to use replaceable filters with corresponding nominal volume resources taking into account the mean daily dispensing volume of each WVM. It is also necessary to select a set of replaceable filters for WVMs based on the consistency of the nominal volume resources of all filters, which will allow replacing the entire set once a year.

Another factor that necessitates frequent visits to the WVMs is the need for cash collections. It may be possible to meet the need for WVM cash collections once every 12 months by increasing the capacity of the WVMs for cash, but such an approach seems risky for the operation of WVMs as devices containing a large amount of money and lacking video surveillance or security. Additionally, cash collection of a large amount of money is inconvenient and dangerous for the collector.

Considering the above, a better solution may be to eliminate cash as a payment method at the WVMs and implement cashless payment methods described in (Murena et al., 2020). The absence of cash accumulation will eliminate the need for cash collections altogether and make the operation of WVMs safer.

Based on the established influence of digitization on the cost of water, it is possible to calculate the forecasted cost under the conditions of meeting the requirements for the operation of WVMs. Namely:

- nominal filter resources are balanced with each other and ensure the operation of WVMs for 12 months with an average daily water consumption of 350 dm^3;
- all filters are replaced once every 12 months;
- expenses on cash collection are absent.

Table 6. *Cost of purified water under time-based servicing logic and projected under volume-based logic*

Expense item	Time-based logic		Volume based logic		Change
	Expenditure, thousand Euro/year	**%**	**Expenditure, thousand Euro/year**	**%**	
Replacement filters	89	34%	27	17%	-70%
Rent of premises for WVM	62	24%	62	39%	0%
Depreciation of WVM	51	19%	51	32%	0%
Servicing	31	12%	8	5%	-75%
Cash collection	16	6%	0	0%	-100%
Utility payments	13	5%	13	8%	0%
Total	262	100%	161	100%	-39%

As seen from Table 6, the projected cost reduction is 39%, which creates an economic basis for further optimization of WVM operations in the directions mentioned above.

4. Conclusions

Digitalization significantly reduces water vending machine (WVM) operational costs by 20% in Kyiv, Ukraine. This reduction is attributed to decreased expenses: 51% for filter replacements, 13% for maintenance, and 17% for cash collection. To meet WVM servicing regulations, enhancing antiscalant cartridge capacity and aligning filter capacities are necessary. Implementing cashless payment methods, removing cash options, and servicing WVMs annually can cut costs by 39%. This forecast underscores the viability of further optimizing WVMs, offering substantial economic incentives for future research.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

1. Cabane, H.; Farias, K. On the Impact of Event-Driven Architecture on Performance: An Exploratory Study. *Future Generation Computer Systems* **2024**, *153*, 52–69. https://doi.org/10.1016/j.future.2023.10.021.

2. Christian Di Carlo. *Fourth Edition Incorporating the First and Second Addenda Guidelines for Drinking-Water Quality*; 2022.

3. Eddy, W. M. *RFC 9293: Transmission Control Protocol (TCP)*; 2022. https://www.rfc-editor.org/info/rfc9293.

4. Falcone, M.; Salvinelli, C.; Bah, M.; Thomas, E. Effectiveness of a Water-Vending Kiosk

Intervention toward Household Water Quality and Surveyed Water Security in Freetown, Sierra Leone. *Science of The Total Environment* **2023**, *875*, 162447. https://doi.org/10.1016/J.SCITOTENV.2023.162447.

5. Grievson, O.; Holloway, A.; Johnson, B. *A Strategic Digital Transformation for the Water Industry*; IWA Publishing, 2022. https://doi.org/10.2166/9781789063400.

6. In-line Filters. https://www.ecosoft.com/category-ecosoft/in-line (accessed 2024-03-26).

7. Kita, A.; Sihabut, T.; Tantrakarnapa, K. Factors influencing the quality of drinking water from vending machines in the inner city of Bangkok. *Public Health of Indonesia* **2020**, *6* (2), 47–56. https://doi.org/10.36685/phi.v6i2.338.

8. Moommala, N.; Phanucharas, D.; Krichanchai, S.; Kapol, N. *Supervision of automatic drinking water vending machine*; 2021; Vol. 16.

9. Mudryk, R.; Mitchenko, T. Shared automatic drinking water treatment and dispensing systems and methods of their optimization. *Water and Water Purification Technologies. Scientific and Technical News* **2023**, *35* (1), 9–25. https://doi.org/10.20535/2218-930012023281111.

10. Murena, E.; Sibanda, V.; Sibanda, S.; Mpofu, K. Design of a Control System for a Vending Machine. In *Procedia CIRP*; Elsevier B.V., 2020; Vol. 91, pp 758–763. https://doi.org/10.1016/j.procir.2020.04.136.

11. Picardal, M. T.; Rapirap, E. M. G.; Micame, L. I.; Tura, M. J. B.; Barrientos, O. N.; Kimilat, R. A.; Sarnillo, A. C.; Porol, A. L. Drinking Water Quality from Water Vending Machines in Selected Public Schools in Cebu City, Philippines. *International Journal of Environmental Science & Sustainable Development* **2018**, *3* (1), 1–9. https://doi.org/10.21625/essd.v3iss1.253.

12. ระวาดชัย, น.; วรางคณา, แ.; งสิ, ส.; สวัสดิ์, ท.; Ravadchai, N.; Sungsitthisawad, W. Factors Affecting of Drinking Water Quality of Vending Machine. *Asia-Pacific Journal of Science and Technology* **2012**, *17* (3), 480–492.

13. Shakirat Oluwatosin, H. *Client-Server Model*; Ver. IX, 2014; Vol. 1. www.iosrjournals.orgwww.iosrjournals.org.

14. Tyvonenko, A.; Mitchenko, T.; Homaniuk, O.; Vasilyuk, S.; Kosogina, I.; Mudryk, R. Production of physiologically complete drinking water using modified reverse osmosis membrane elements. *Eastern-European Journal of Enterprise Technologies* **2023**, *2* (10–122). https://doi.org/10.15587/1729-4061.2023.277491.

15. *Vseredyni akvaboksu chystoi vody | BWT Aqua (Inside the aqua box of pure water | BWT Aqua).* https://bwtaqua.com.ua/inside-bwt/ (accessed 2024-03-10).

16. Yongyod, R. Drinking Water Quality and Evaluation of Environmental Conditions of Water Vending Machines. *Asia-Pacific Journal of Science and Technology* **2018**, *23* (1).

ЦИФРОВІЗАЦІЯ ВОДНИХ ВЕНДИНГОВИХ АВТОМАТІВ

Мудрик Р.Я.[1], *Орестов Є.О.*[1]

[1] Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського», Київ, Україна, 03056, rostyslav.mudryk@gmail.com

Дана стаття присвячена дослідженню впливу цифровізації на роботу водних вендингових автоматів. Автомати є сучасним способом отримання безпечної фізіологічно повноцінної питної води. Їх перевагою є автономність роботи без постійної присутності обслуговуючого персоналу. Це досягається заміною фільтрів та обслуговуванням, які здійснюються за часовою логікою. Часова логіка не враховує фактичні об'єми очищеної води, тому при роботі мережі спостерігається перевитрата коштів на обслуговування одних апаратів і невчасне обслуговування та погіршення якості очищеної води для інших. В даній роботі досліджувався вплив цифровізації на оптимізацію витрат на обслуговування та собівартість очищення води. Показано, що завдяки цифровізації було змінено логіку обслуговування на об'ємну та скорочено витрати на змінні фільтри (51%), сервісне обслуговування (13%) та інкасації (17%). Сумарно ці фактори зменшили собівартість води на 20%. Зниження собівартості підвищує прибутковість роботи мережі автоматів. При фіксованій ціні води, це єдиний спосіб збільшення прибутковості і зацікавленості інвесторів та як наслідок популяризації водних вендингових автоматів. Наступні дослідження будуть присвячені пошуку альтернативних фільтрів, матеріалів та технології підготовки води для досягнення ще більшої автономності апаратів. Завдяки встановленому впливу цифровізації на роботу водних вендингових автоматів розрахована прогнозна собівартість води при виконанні всіх вимог до їх роботи. Прогнозне зменшення собівартості складає 39%, що закладає економічне обґрунтування для майбутніх досліджень.

Ключові слова: *зворотний осмос, інтернет речей, оптимізація, питна вода, собівартість, технології водопідготовки*