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Phytoarchitecture Integrates Hybrid Onsite Phytosanitation to Suppress Building Environmental Pollution

Harida Samudro[1] | Ganjar Samudro[2] | Sarwoko Mangkoedihardjo[3]✉

1. Department of Architecture, State Islamic University of Malang, Malang, Indonesia.
2. Department of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia.
3. Department of Environmental Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia.

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ABSTRACT

Efficiency of environmental resources is one of the goals of the sustainable development of a building and its sanitation. Sanitation efficiency was sought through hybrid offsite system, which was a decentralization of sanitation services. This study proposed a hybrid onsite system combining phytoarchitecture and phytosanitation, which empowers renewable building plants to improve resource efficiency, as well as sustainable building environmental health. Based on various empirical studies on sanitation management in rural and urban areas in many places, this retrospective study identified three wastewater disposal efficiencies. It was through quantity distribution, environmental media in which the greywater could be discharged, and quality treatment. The results marked the feasibility of wastewater services for greywater treatment, which served at least 75% of the wastewater quantity. Its main contribution was related to the distribution of discharge to all environmental media, and the improvement of the quality of greywater at its disposal. Building plants could be used for hybrid onsite system, thereby making these plants multifunctional to maintain the quality of the building environment. This hybrid onsite phytosanitation system covered various feasibility features compared to other existing systems. Implementation was flexible for new provisions and adaptation to existing systems for both urban and rural areas. Thus, the service maintained sustainable buildings and environmental health.

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INTRODUCTION

The three social, economic and environmental pillars constitute the platform for sustainable development goals (Purvis et al. 2019), which are implemented through various approaches. Sustainable city uses a paradigm as an efficient service place for residents' activities (Vardoulakis and Kinney 2019). The scope of city services at least includes integrated infrastructure and a sustainable built environment including green building design (Eghbali and Didari 2018). Green building refers to the creation of building structures that are functionally resource efficient and environmentally friendly throughout the chain of design, construction, operation, maintenance, renovation and deconstruction (USEPA 2016), thus green building is nothing less than sustainable building.

Sustainable building requires renewable resources (Dđkmen and Gültekđn 2011), which can be met by plants as renewable natural resources. Thus, there is a phytoarchitecture, which is defined as the provision of space for plants and empowering them for processing and managing

*Corresponding Author Email: *prosarwoko@gmail.com*

the environmental quality of a building space, which includes indoor and outdoor within the boundaries of the building area. Thus, phytoarchitecture is nothing less than onsite greenspace. It is to encourage the empowerment of building plants for preventive measures (Samudro et al. 2022a) and remediation of polluted environment (Samudro and Mangkoedihardjo 2021).

Meanwhile, sanitation is an essential service for human life, which uses a sustainable approach based on technical feasibility, economic viability, financial affordability, social acceptance, institutional guidance and environmental protection (Schroeder 2022). With reference to sustainable sanitation (Hutton and Chase 2016), for a building is closer to the efficiency of clean water use which results in efficient wastewater discharge of good quality for the environment. The building wastewater covered in domestic activity, which includes waste from personal hygiene, kitchen work, washing goods and vehicles as well as cleaning of buildings and courtyards (Ghawi 2018). Currently, building sanitation management can use an onsite system, where wastewater is processed and disposed of within the building boundaries (Ghangrekar 2022). Onsite systems usually place a septic tank as a wastewater treatment plant below ground level, and the waste flows to the ground and/or drainage ditch (Shivendra and Ramaraju 2015). Building sanitation can also be managed in the form of offsite system, where septic tank effluent and/or wastewater from buildings flows directly in a network of conveyance sewers to wastewater treatment outside the building boundaries with centralized, decentralized and hybrid options (Manga et al. 2020). The main feature of wastewater disposal for all these systems is releasing the quantity and quality of wastewater to the environment outside the building area as much as it is generated at the source.

Thus, there is a gap in the implementation of wastewater disposal, resulting in resource inefficiencies for all existing sanitation systems. This gap includes the distribution of the quantity of wastewater disposal, the lack of utilization of environmental media for disposal, and the treatment of wastewater quality. As a result, there is room to improve resource efficiency for all existing sanitation systems. For this reason, this paper proposed a new sanitation system intending to obtain specific features of efficient wastewater quantity to reduce discharge, efficient wastewater quality to reduce pollution load, integrate building plants to gain environmental-added value, and complete onsite management to encourage social participation and reduce institutional engagement. These features lead to an efficient use of resources for the provision of sanitation facilities, thereby bringing closer to the economic feasibility and financial affordability for the implementation of construction, operation and maintenance. These achievements are significant supports for sustainable building sanitation in particular and sustainable development in general.

MATERIALS AND METHODS

This study is a literature review that reports on the performance of onsite sanitation, offsite sanitation, domestic wastewater treatment, and the use of plants as biological media to improve the quantity and quality of wastewater.

Literature selection criteria included current facts from the last 15 years, diversity of onsite and offsite sanitation systems, diversity of environmental conditions in which sanitation systems exist, experience using plants to treat wastewater, and literature sources from reference platforms published in Scopus, Web of Science, and Google Scholars. Based on the selection criteria, a total of 96 literatures were obtained for assessing the research results. Furthermore, the assessment criteria include the simplicity of the system and its operation, the use of physical and biological media in processing quantity and quality, as well as the flexibility of modifications to adapt to other environmental conditions.

Based on this assessment, a new system is proposed to the integration of the phytoarchitecture of a building as an onsite sanitation management unit. Building phytoarchitecture can significantly support the health of buildings and their occupants (Samudro et al. 2022b). Several specific features of each sanitation system are presented to be considered for implementation under local environmental conditions.

RESULTS AND DISCUSSION

Existing sanitation systems

The wastewater sanitation management (Savković-Stevanovic 2013) includes collection, conveyance in sewers, treatment and disposal facilities. Wastewater management can separate blackwater or human waste and greywater, as well as mixed.

For offsite sanitation systems, except for collection, other facilities are outside the building boundaries (Safi et al. 2022). Offsite sanitation systems vary (Affam and Ezechi 2020) depending on the type of wastewater being discharged, such as conventional and shallow sewers (Öberg et al. 2020) that convey black and greywater, as well as small bore sewers for septic tank effluent (Nawrot et al. 2018). On a service management scale, off-site sanitation can include centralized system serving one service area, decentralized system serving a group of buildings, which had been adapted as modular system (Gupta et al. 2022). In addition, there is a hybrid system (Maurer 2022) when centralized and decentralized management scales exist within the same service area. Offsite systems may use plant processing for resource recovery, such as constructed wetlands (Capodaglio et al. 2021). In certain field conditions, the offsite wastewater system uses rainwater drainage channels, known as a combined sewer system (Bachmann-Machnik et al. 2021).

As for the onsite sanitation system, all management chains are within the boundaries of the building area. Even if the existing onsite system provides a septic tank, the blackwater that is deposited as a septage in the tank is emptied and treated outside the building (Bao et al. 2020), hence the onsite system basically handles the greywater. Greywater and septic tank effluent are usually discharged into local soil absorption (Hu et al. 2007), as well as into rainwater drainage ditches around building boundaries (Alexander and Godrej 2015). Thus, onsite sanitation system is generally susceptible to contamination of groundwater quality (Quamar et al. 2017), and resuspension of contaminants during the rainy season (Gadhia et al. 2012).

Quantity distribution

The quantity of wastewater determines the design capacity of sanitation infrastructure. For existing sanitation systems, design capacity is based on peak hourly discharge (Imam and Elnakar 2014). The peak discharge is roughly the same as clean water usage at peak hours, and estimated to be more than five times the daily average for serving up to ten people in a single building (Balacco et al. 2017). In addition, sanitary facilities must be designed for long-term service by adjusting the functional lifetime of the facilities (Poduška et al. 2019). Therefore, the dimensions of the facility are designed for tens of years quantity.

The consequence of long-term design is the presence of idle capacity (Kherbache and Oukaci 2020), as the available capacity of facilities that is not utilized by working capacity. Idle capacity occurs from the start of operation to the end of the design period. In addition to investment losses, internal material that has not been utilized can experience a decrease in material quality due to the influence of wastewater quality (Sakson et al. 2022), thereby reducing the functional lifetime of the facility. Moreover, idle capacity decreases the flow rate in the facility, which accelerates the settling of solids wastewater and increases the frequency of flushing (Melville-Shreeve et al. 2021), leading to wasteful use of water. In short, idle capacity results in wastage of resources, as opposed to resource efficiency for sustainability. This is a common feature of sanitation facilities designed for long-term service, such as onsite and offsite systems.

Efforts to reduce idle capacity consider the following three approaches. The first approach is quantity distribution by separating blackwater and greywater. Greywater is wastewater other than human waste from toilets (Oteng-Peprah et al. 2018) to be discharged into a septic tank onsite. The quantity of greywater is around 75% of the amount of households wastewater (Hernández Leal et al. 2010), which is considered to reduce idle capacity.

The second approach, a sanitation system can use a decentralized modular sewerage to serve a group of buildings (Massoud et al. 2009), where fluctuations in water use are uniform and more even throughout the day. With this modular service, the peak hourly factor of water use can be minimized, and the service design period is shortened (Wang 2014). As a result, the dimensions of sanitary facilities can be reduced, the frequency of flushing is reduced, while the service lifetime of materials is extended. An illustration of the significance of a decrease in idle capacity, suppose a city with a population of one million people has a peak hourly wastewater discharge of five times the daily average discharge (5Q). The modular system is applied to serve a group of buildings with uniform fluctuations throughout the day, so the peak hourly discharge is less than that of the city, take the example of 2Q.

Hybrid onsite phytosanitation

The third approach to decreasing idle capacity is the new option, called hybrid onsite phytosanitation system. The main features are the distribution of quantities to various environmental media (soil, water, air, plants) and the treatment of qualities involving plant processes. This system works inside the building yard and the treated effluent can be discharged into the drainage ditch at the building boundary. Introducing plants to onsite sanitation has added value for the health of building occupants besides being very environmentally friendly. Owing to this new system uses building plants, it is suitable for treating greywater, which accounts for a large portion of the quantity of wastewater discharged from a building. Apart from greywater, the new system can also be used to treat septic tank effluent, displacing soil absorption, thereby reducing groundwater pollution.

As the definition of hybrid offsite, the hybrid onsite phytosanitation is the coexistence of existing onsite system, which treats blackwater in septic tanks, and phytosanitation, which treats greywater and septic tank effluent, within one service area. This hybrid onsite phytosanitation system works on a source of wastewater, hence it can be managed independently. The existence of idle capacity which characterizes the weakness of the offsite system can be eliminated by the hybrid onsite system, thereby reducing the wastage of resources.

Overall sanitation management systems are presented in Figure 1, showing the position of proposed hybrid onsite phytosanitation system.

The hybrid onsite phytosanitation system is flexible in its application both in rural and urban

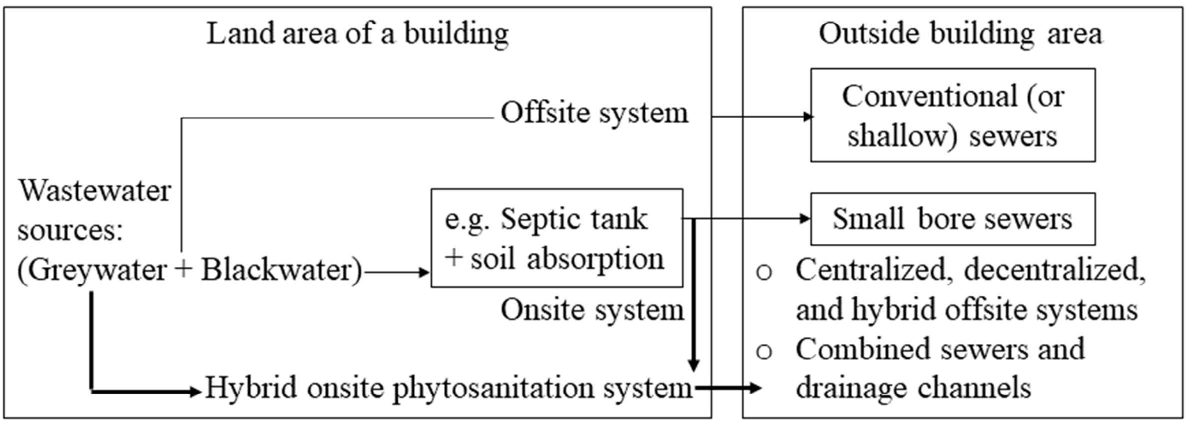

Fig. 1. Overall sanitation management systems

areas. It can be designed and implemented for new buildings, and can also modify or replace other existing systems with some necessary adjustments. Thus, its application does not require a lot of resources, but supports the feasibility of sustainable sanitation.

Environmental media distribution

For the new hybrid onsite phytosanitation option, the method of distributing the quantity of greywater is to various environmental media placed at the wastewater source. The various environmental media are soil, water, air, and plants, in evaporation (Menon et al. 2020) and/or evapotranspiration beds (Paulo et al. 2019). Figure 2 illustrates the distribution of greywater quantity from source to environmental media for phytosanitation. Therefore, the significance of the distribution of the quantity of phytosanitation is the number of environmental media into which the discharge flows.

Evaporation beds that are practical for building contain granular soil media and the like, in which a portion of the greywater is evaporated into the air. The quantity and rate of evaporation of greywater through the soil surface is difficult to generalize, because it is influenced by the physical and chemical characteristics of the soil, its transport processes and environmental conditions (Han et al. 2017). Therefore, no matter how small the release of greywater into the air results in a reduction in the amount of greywater released from the evaporation bed. When the granular media is planted with plants, it acts as an evapotranspiration bed (Velychko and Dupliak 2021). The quantity and rate of evapotranspiration are also influenced by factors influencing evaporation with the addition of plant species (Weiss et al. 2021). Owing to plants use water to maintain their growth, the amount of greywater that is wasted outside the evapotranspiration bed becomes less than that released from the evaporation bed.

With the use of these beds, the flow of greywater into the sanitation facilities, as well as the design dimensions are smaller compared to the existing onsite and offsite sanitation systems. In short, the reduced dimensions of sanitation facilities due to onsite phytosanitation interventions are closer to economic feasibility and financial affordability for construction, operation and maintenance.

Quality treatment

The quality of greywater can contain toxic organic compounds such as those derived from chemical products (Bearth et al. 2020), various organic compounds (Noman et al. 2019), and various inorganic materials, however, they can be treated biologically (Eriksson et al. 2010). Several other inorganic substances, such as N and P have nutritional value for plants (Razaq et al. 2017), which are not considered by the existing onsite and offsite sanitation systems. With the use of evaporation beds, the concentration of biodegradable organic matter can be reduced by soil microbes (Gnowe et al. 2020), thus improving the quality of greywater flowing

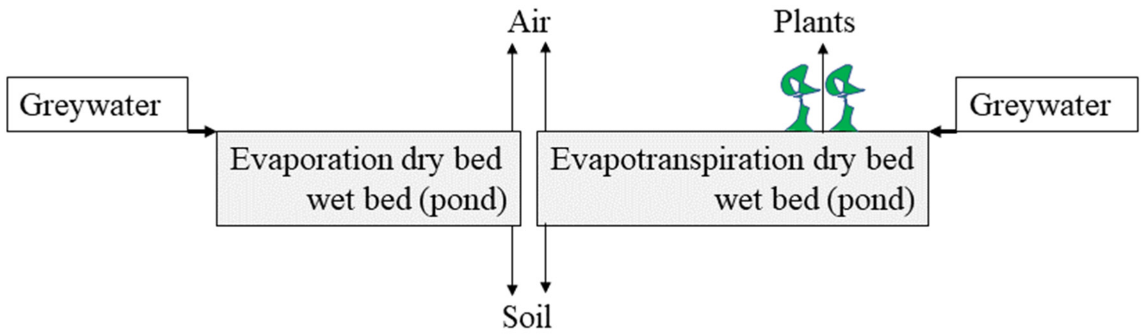

Fig. 2. Greywater quantity distribution by phytosanitation

into sanitation facilities. Further improving the quality of greywater streams is the use of evapotranspiration beds, which reduce the concentration of organic matter by soil microbes and convert it to minerals, thus enriching inorganic matter for plant nutrients uptake (Chazarenc et al. 2010). Figure 3 is a greywater quality treatment scheme for phytosanitation options.

Plant processes determine the improvement of greywater quality, especially phytostabilization (Radziemska et al. 2017) as a process of immobilizing greywater contaminants in the plant growth media. Collection of contaminants in the root zone is caused by transpiration carried by plants (Pieruschka et al. 2010). In general, all types of contaminants undergo a process of phytostabilization. The next process is rhizofiltration (Woraharn et al. 2021), which refers to the process of adsorption or precipitation of contaminants on the roots or absorption into the roots. Along with that is the process of rhizodegradation (Allamin et al. 2020), which decomposes contaminants in the soil by microbial activity. Generally, contaminants that undergo microbiological processes are organic contaminants that are easily decomposed microbiologically (Dicen et al. 2020), and inorganic contaminants such as ammonium and nitrite (Norton and Ouyang 2019), as well as heavy metals (González Henao and Ghneim-Herrera 2021).

Greywater can carry pathogenic microbes, which can be eliminated by plants through the process of phytomicroremediation (Singh et al. 2016). A study (Samaddar et al. 2021) showed that pathogenic microbes in plant media live shorter lives than in soil and in fresh and greywater. The cause of the short duration of pathogenic microbes in plant media is the quality of the exudate (Doornbos et al. 2012), which is able to eliminate pathogenic microbes but has no effect on the microbes living in the roots (Farraji et al. 2020). Besides, pathogenic microbes are external inputs into plant irrigation (Xue et al. 2020), so they are not adaptive to plant root conditions. This fact strengthens the use of plants to treat greywater and remediation of the soil environment contaminated with pathogenic microbes.

The above processes can run simultaneously, after which the plant carries out the phytoextraction process (Hunt et al. 2014), absorbing contaminants from the growth medium. Contaminants absorbed by plants are then distributed or translocated into various plant organs (Limmer and Burken 2014). The contaminant absorption process takes place in line with

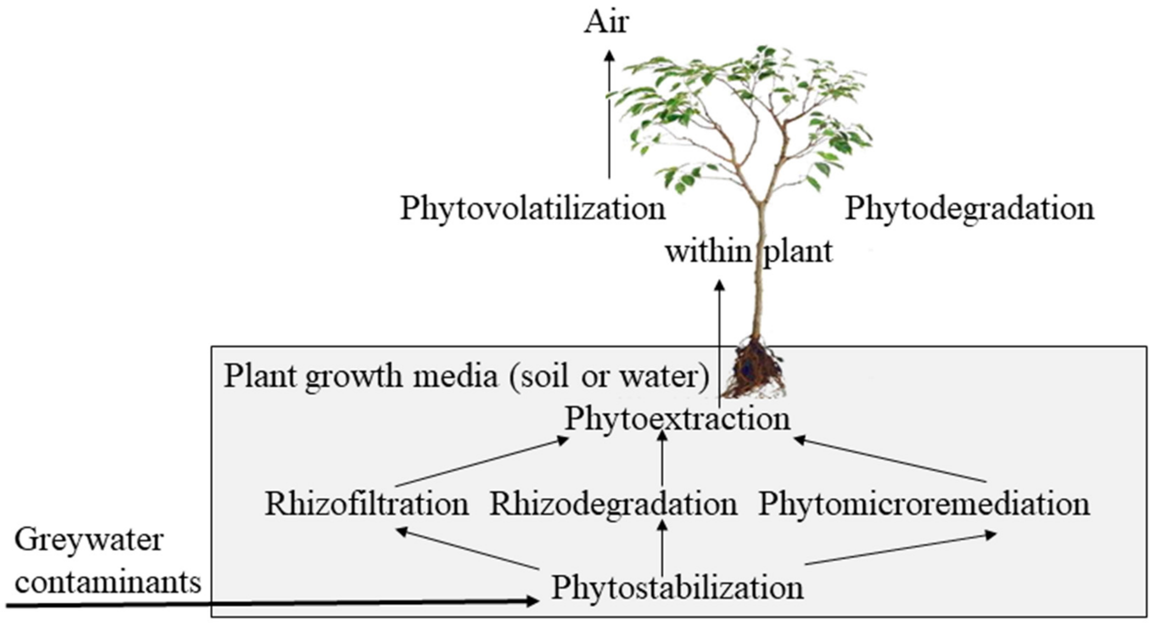

Fig. 3. Greywater quality treatment by phytosanitation

the transpiration flow when the transpiration process occurs (Winkler and Knoche 2021). Contaminants absorbed into plants are generally water-soluble contaminants (Nedjimi 2021). However, some substances that are difficult to dissolve in water can be absorbed by plants, for example oil (Effendi et al. 2017), which is caused by dissolving plant exudate. Thus, the exudate functions as an organic solvent and also determines the solubility of contaminants. In plants, contaminants can be degraded through phytodegradation processes by means of metabolic processes in plants (Orlanda 2019). The process of phytodegradation allows contaminants to be converted into plant nutrients.

The final process of plants is phytovolatilization (Limmer and Burken 2016), which is the process of releasing contaminants into the air after being absorbed by plants. Absorbed contaminants can change their chemical structure before being released into the air (Q. Zhang et al. 2020). All substances have different levels of vapor pressure, which determines the degree of phytovolatilization. Volatile organic carbon, for example alcohol, undergoes more phytovolatilization than heavy metals which have a very low vapor pressure for the same concentration (Menezes et al. 2013). In the case of greywater treatment containing organic matter or oil phytoremediation, there is little concern that oil accumulation in plants is small, but caution is needed for its release into the air. Likewise, the treatment of greywater containing heavy metals or phytoremediation of soil contaminated with heavy metals, the concern for the release of heavy metals into the air is very small, but it is necessary to be aware of the accumulation of heavy metals in plants (Uddin et al. 2021).

Phytoarchitecture design

The aforementioned definition of phytoarchitecture was formulated from the concept of environmentally sound architecture, which is defined as the art of designing buildings that are livable, resilient, healthy and comfortable (MCH 2019). The technical function of building phytoarchitecture emphasizes the ability of plants to manage environmental quality, including the ability to eliminate pollutants both for indoor (Apte and Apte 2010) and outdoor (Lee et al. 2021). This is the added value of using plants for the building environment and for the health of occupants. Further development for buildings with limited or no open courtyard space, the spatial arrangement of plants can be aerial and/or vertical, such as green roofs and green walls, as well as skygarden forms (Tien et al. 2021).

Incorporating phytosanitation into phytoarchitecture can use evapotranspiration beds. There are two types of evapotranspiration beds according to the type of plants used. Evapotranspiration dry bed is mounds of water-unsaturated soil on which terrestrial plants grow (Velychko and Dupliak 2021). While the evapotranspiration wet bed is water-saturated soil in the form of a pond, where aquatic plants grow, such as constructed wetland (Milani et al. 2019).

The technical function of plants can be as facades for sun exposure barriers (Sheweka and Mohamed 2012), which have the ability to control indoor air temperature. In addition, they have the ability to capture and treat a variety of outdoor air pollutants (B. Zhang et al. 2020), which in equilibrium indoor/outdoor concentrations contribute to improving indoor air quality (Saxena and Sonwani 2020). As an alternative to the facade is a green fence, to position the evapotranspiration beds on the boundaries of the building area. This green fence acts as a roadside plant to attenuate contaminants from road traffic activity (Azhari et al. 2011). Figure 4 illustrates the green facade and fence as a greywater evapotranspiration dry bed.

The existence of evapotranspiration beds is improving the quality of greywater, and the quality of surrounding air. The processes of plants that capture air are phytosequestration (Jansson et al. 2010). This process is in line with the processes of photosynthesis and respiration, which show the uptake of gases from the air into plants through the leaves. Phytosequestration marks the important contribution of air pollution control for indoor and outdoor environments of buildings.

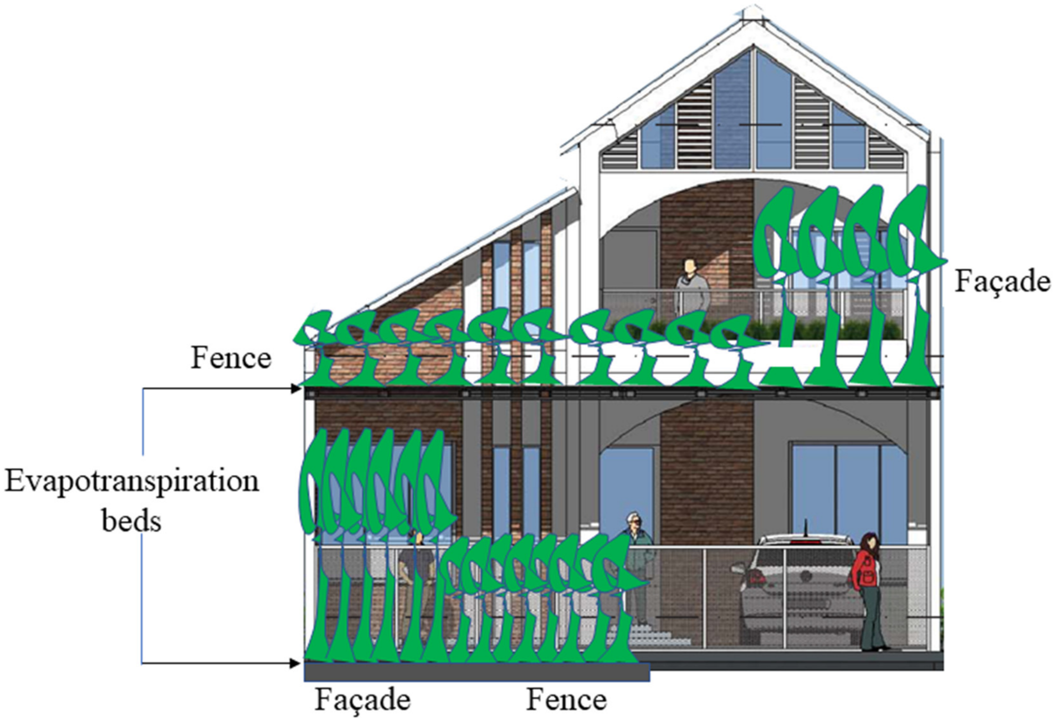

Fig. 4. Green façade and fence for evapotranspiration dry bed

As a green facade option is the use of plants that are able to climb, such as *Mitraria coccinea*, *Cissus striata*, *Boquila trifoliolata*, *Hydrangea serratifolia*, *Elytropus chilensis* and *Luzuriaga radicans* (Valladares et al. 2011), as well as *Parthenocissus tricuspidata*, a common plant species associated with buildings (Zhou et al. 2021). The plant medium for climbing can be a grid of any material that is installed vertically up to the height of the building that requires sun protection. Beneath the grid is a plant growth medium, which also functions as an evapotranspiration dry bed, where greywater is channelled into the bed.

From a socio-economic perspective, the utilization of plants can use various types that can have medicinal properties. The application of plant diversity takes into account local wisdom that is unique and develops in certain conditions and geographical areas (Sukkho et al. 2022). This local wisdom incorporates the experience, expertise and insight possessed by the local community to maintain and improve livelihoods, so that it becomes an important factor in sustainable development. There were many medicinal plants available and used in Asia (Sanusi et al. 2017). The use of local wisdom plants also determines the adoption of phytosanitation as an option for treating greywater according to people's preferences (Mousavi Samimi and Shahhosseini 2021).

The use of plant diversity is recommended (Samudro and Mangkoedihardjo 2020) taking into account the presence of various substances in the greywater, and the various protective functions of the building (Gubb et al. 2020), as well as the preferences of the occupants (Behe et al. 2013). The diversity of plants meets the balance of the three pillars of sustainable development.

Placement suitability

The green facade and fence are suitable for limited outdoor space. Placement of both is prioritized on the side of the building which gets the longest exposure to sunlight throughout the day, which can be the east or west part of the building. This placement supports as much greywater evapotranspiration as possible. The arrangement of potted building plants in several parts of the building can actually function as evapotranspiration dry beds. Its placement is not limited to building yards, but can also be applied to multi-storey buildings, for example on balconies and corridors as shown in Figure 4. In conditions where sky gardens (Tian and Jim 2012) are available in the building, it can be integrated as a phytosanitation system to treat greywater. For building aesthetics, phytoarchitecture experts are able to design aerial greywater treatment operations. The main spirit of the evapotranspiration bed function in these conditions is the greywater recovery resources.

For buildings with sufficient yard area and settlements in contoured landscapes (Samudro 2020), in addition to using evapotranspiration dry bed is evapotranspiration wet bed in the form of pond. The evapotranspiration wet bed is nothing less than constructed wetland, which can be small scale for a single building (Wallace 2006), where greywater is treated by aquatic plants. Figure 5 illustrates the design of two types of evapotranspiration beds, which are applied in combination.

The combined evapotranspiration beds can operate independently, as well as sequentially (Samudro and Mangkoedihardjo 2020). Independent operations indicate the inflow of greywater into each bed. The sequential operation shows the flow of greywater entering the evapotranspiration wet bed, from which it continues capillary flow to the evapotranspiration dry bed (Bin Zainal Abidin et al. 2014). Sequential operation is advantageous when the greywater contains toxic organic matter. The media of evapotranspiration beds can detoxify toxic organic matter microbially, further achieving quality stability, while not having a negative effect on plant life (Das et al. 2022).

In practice, there is a sanitation system that discharges greywater into drainage ditches and poses a risk to public health (Ali et al. 2021). However, in these two building conditions and the amount of greywater that exceeds the disposal capacity at the site, the greywater treated by plants can be channelled into drainage ditches around building boundaries. Plants are able to detoxify chemicals contained in greywater (Widdup et al. 2015), hence it is safe enough to be discharged into the drainage ditch.

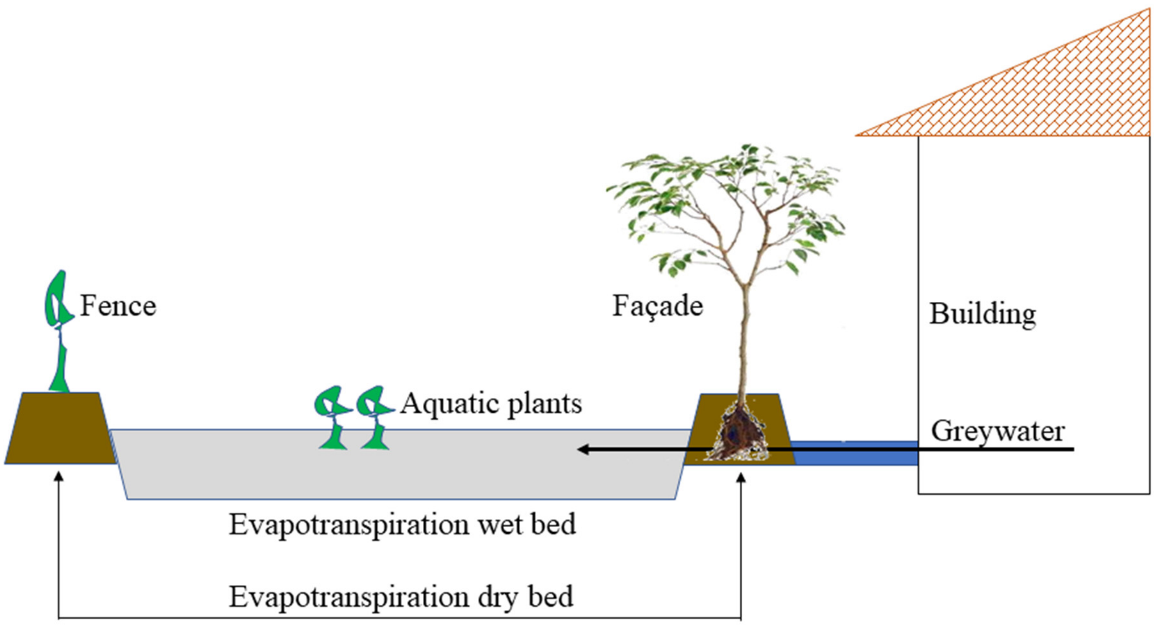

Fig. 5. Combination of evapotranspiration dry bed and wet bed

Table 1. Sanitation features

Features	Offsite system	Onsite system	Hybrid onsite phytosanitation system
Technical			
Blackwater	Applicable	Applicable	Not applicable as is, but applicable to septic tank effluent
Greywater	Applicable	Applicable	Applicable
Quantity (Q) distribution	100%Q to single medium (sewer)	At least 75%Q to single medium (soil)	At least 75%Q to multimedia (soil, water, air, plants)
Idle capacity of sanitation facilities (Kherbache & Oukaci, 2020)	High potential	Ignored	Ignored
Implementation flexibility	Hybrid system (Roefs et al., 2017)	It can be channelled into small bore sewer (Barasa, Godfrey Masinde 2020)	It can replace soil absorption of septic tank effluent, and channel to drainage ditch
Economic			
Resources recovery	Offsite	None	Onsite
Economic value	Offsite	None	Using decorative and medicinal plants
Financial			
Investment	Institutional funding	Self-help	Self-help
Operation and maintenance	Institution management	Self-help	Self-help
Social			
Community participation	Institutional support	Self-help	Self-help
Private sector involvement (Ndaw, 2016)	Septage emptying	Septage emptying	Septage emptying, and plant selling
Institutional			
Regulations (Hashimoto, 2021)	Applicable	Applicable	Applicable
Management agency	Applicable (Hashimoto, 2021)	Self-help	Self-help
Environmental			
Service area	Urban for limited building area	Rural for sufficient building area	Urban and rural without building area limitations
Quality treatment	Offsite	Onsite but prone to pathogen flows (Amin et al., 2020)	Onsite with less pathogen flows due to phytomicroremediation process (Singh et al., 2016)
Phytoarchitecture utilization	None	None	Integrated
Building and environmental health	Supportive	It is less supportive than offsite	It is more supportive than offsite and onsite with an increase in air quality from the sequestration process of airborne contaminants (Jansson et al., 2010)

Sanitation features

In summary, the potential feasibility features of the existing and proposed sanitation systems are presented in Table 1. Feasibility includes technical, economic, financial, social, institutional and environmental aspects (Schroeder 2022). One may improve to this list of potential features according to local conditions.

CONCLUSIONS

Within the framework of sustainable building, a new hybrid onsite phytosanitation system in phytoarchitecture is proposed to improve the efficiency of the sanitation system involving plants. This system works with two forms of technical intervention simultaneously, which are fully managed at the source of the greywater discharge. The first is the distribution of the quantity of greywater to various environmental media, thereby minimizing discharge to the outside of the building. The second is greywater quality treatment that is integrated with phytoarchitecture, in which building plants deconcentrate various greywater chemicals. In addition, this integrated system produces economic resources in the form of the plants themselves and environmental resources that are beneficial to the health of the building and its occupants. Since management is entirely at the source of the greywater, the integrated system encourages social participation by occupants in the provision of facilities, operation and maintenance, thereby reducing institutional involvement. This new system can meet the feasibility of provision of sanitation infrastructure and sustainable development goals.

AUTHORS' CONTRIBUTIONS

HS: conception, design, acquisition of data, analysis and interpretation of data, drafting the manuscript, revising it, focusing on building phytoarchitecture; GS: as did HS' contribution, focusing on onsite phytosanitation; SM: as well as the contributions of HS and GS with the addition of plant processes.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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