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Utilization of Wastewater Management for Sustainable City Environment in Abuja, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author EHM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CBM managed the analyses of the study and author MA managed the literature searches and supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

Wastewater contribute to many damages to the ecosystem and biodiversity, it encompasses domestic, commercial, industrial and agricultural components and also faecal sludge, to prevent this sensitive damage, wastewater need to be well treated before being discharged to the environment or water bodies, otherwise it contributes to some disease outbreak like malaria and typhoid. Extreme poverty with inequality of income, housing system and poor urban planning combined with rapid increase in population mostly found in low/lower class settlement are among those factors contributing to these challenges and this study determines the health and environment impact of untreated wastewater. The comparative study was carried out in two study areas; highbrow areas that makes use of central wastewater treatment plant known as "WUPA" and low/lower income areas that practice open surface wastewater discharge, to determine how frequent both residents treats malaria/typhoid and soil pH value of the study areas also analyzed.
In-house survey questionnaire for 300 respondents of children below 12 years was employed which show that average 65% of residents in highbrow areas treated both malaria/typhoid once in 6

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months, while 64% in the low/lower class areas treated 4 times in 6 months and with an average pH value of 8.18 for highbrow areas and 7.51 for low/lower class areas. This study recommends that government should connect all areas to the treatment plant, implement proper urban planning, awareness and with enforcement.

Keywords: Wastewater; treatment plant; soak-away; malaria/typhoid; soil pH.

1. INTRODUCTION

According to United Nation water analytical brief Wastewater encompasses domestic, commercial, Industrial and Agricultural components and also faecal sludge, presently only 20% globally produced waste-water receive proper treatment UNESCO [1]. Treatment capacity typically depend on the income level of the country, thus treatment capacity is 70% of the generated wastewater in high income countries compared to only 8% in low income countries Sato [2]. This wastewater contribute to many damages to the ecosystem and biodiversity, according to millennium ecosystem assessment 2005 reported that 60% of global ecosystem services in which many social and economic activities depend on are being degraded or used unsustainably and highlighted the inextricable links between ecosystem integrity and human health and well-being.

A paradigm shift is required to prevent further damage of sensitive ecosystem like; vegetation and aquatic environment but also to emphasize that wastewater is a resource if effective utilized it will be of important to our water security Corcoran et al. [3]. This wastewater can be recycled and reused for different purposes like domestic, industrial, agricultural and watering of vegetation around us. This treated wastewater reuse is a sustainable way of addressing long term imbalances between water dam and supply, it makes economic sense also in view of increases imbalances due to climate change Drechsel et al. [4]. Waste-water may contain organic substances and nutrient that may be of value to agriculture if well treated, and hazardous if discharged without treatment for it contains chemical or pathogens. According to World water council and UN-Water; if water bodies receive this nutrient in excess amount, there will be excess stimulation of plant growth that will release toxin into the water bodies that leads to oxygen depletion and de-oxygenated dead zones and this effect biodiversity, changes species composition, dominance and decrease water quality for reuse. This waste-water treatment also emits methane and nitrogen oxide, a very powerful global warming gases which recorded an increase of 50% to 25% between 1990 and 2020 Corcoran et al. [3].

Region with water scarcity experience disparity in access to water due to competition for the limited resource and poor people are the mostly effected UNEP [5]. Achieving the sustainable development goal 6, which target improvement of wastewater management contentiously and put pressure on poor developing countries Hutton [6]. Increase in population, poor infrastructure and lack of wastewater treatment plants are the major problem of developing countries in achieving sustainable wastewater management. Wastewater generated in Nigeria are largely discharged direct to the environment through difference processes namely:

- Sewage treatment plant process
- Septic tanks/Soak-away process
- Open surface discharge process

Two of these processes degrades the environment and in turn contaminates groundwater, affect the vegetation and causes pollution due to lack of proper disposal process that involves treatment before being discharge direct to the environment and main focus of this study is Open surface discharge that is unsustainable and unsafe to health and environment. According to WHO an estimated 1.8 million children under the age of 5 years old die every year due to water related diseases in developing countries.

Sewage treatment plant process: This are the process of removing contaminants from wastewater, mainly from household sewage and some processes are involved in removing this contaminants like physical, chemical and biological processes which turn out to produce treated wastewater or effluent that is more safer to the environment. By-product of this treatment is usually semi-solid waste or slurry called sewage sludge. This sludge will still undergo more treatment before its suitable to land for final disposal and application. It can also be referred as wastewater treatment in broad team when

household and industrial effluents are being combined like it had been practiced in some cities with pretreatment from the industries to reduce pollutant loads. This process is the best treatment for liquid waste and is been practiced in some cities of the country like FCT, Abuja but covers not all the city districts. Liquid waste generated from few connected districts of the city are channeled to the treatment plant known as WUPA treatment plant before been discharged to the environment after treatment. The treatment process in the plant can be divided into physical, biological and discharge phase. The physical phase is the primary process while the biological phase is the secondary process and the discharge process known as tertiary phase.

Primary phase:

i. Sewage flow from the sewers across the city center flown by gravity to the treatment plant through a trunk sewer of 1.6 mm diameter.
ii. Coarse Screen used for trapping and removing of debris.
iii. Fine Screen that helps in removing all organic waste from the sewage.
iv. Clarifier is used to settle sludge while grease and oil rise to the surface and skimmed off.

Secondary phase:

i. Bioreactor contains mixers and mammoth rotor that introduce molecular oxygen called dissolver, dissolve oxygen into the system, to mix the sewage and avoid sedimentation. The microorganisms require the dissolved oxygen to act and degrade the sewage, bioreactor uses the activated sludge system with extended aeration.
ii. Sedimentation Tank is the final step in the secondary treatment stage used to settle out the biological flow or filter material through a secondary clarifier and to produce sewage water containing low levels of organic material and suspended matter.

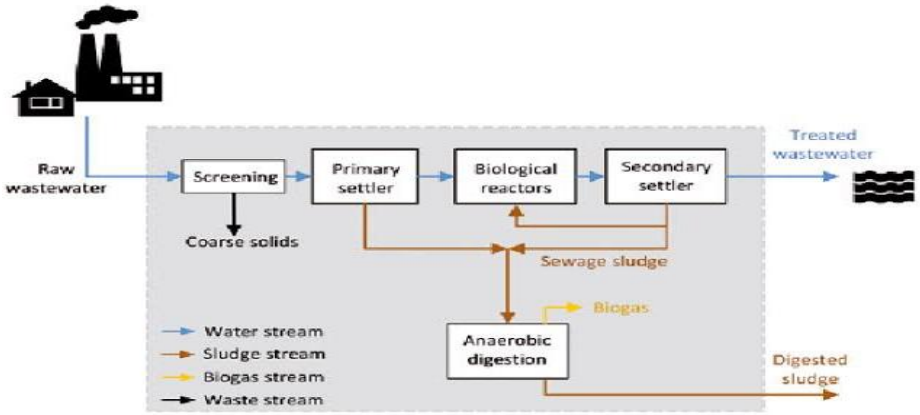

Fig. 1. WUPA aerial view and schematic diagram of treatment plant [7]
Sources: Abuja WWTP. Bachmann et al. [8]

Tertiary phase:

i. **Disinfection:** The purpose of disinfection in the treatment of waste water is to substantially reduce the number of microorganisms in the water to be discharged back into the environment for the later use for drinking, bathing, irrigation and others. The effectiveness of disinfection depends on the quality of the water being treated like; cloudiness, pH and others. The type of disinfection being used are; disinfectant dosage "concentration and time" and other environmental variable. Cloudy water will be treated less successfully, since solid matter can shield organisms, especially from ultraviolet light or if contact times are low. Generally, short contact times, low dose and high flows all militate effective disinfection. Common methods of disinfection includes ozone, chlorine, ultraviolet light, or sodium hypochlorite.
ii. **Sludge Treatment and Disposal:** The sludge accumulated in wastewater treatment process must be treated and disposed through safe and effective manner. The purpose of digestion is to reduce the amount of organic matter and the number of disease-causing microorganisms present in the solids. The most common treatment options include anaerobic digestion, aerobic and composting. Incineration is also used, albeit to a much lesser degree. The sludge passed through a process called pre-thickener which de-waters the sludge.

The Wupa Sewage Treatment Plant uses Ultraviolent (UV) light to disinfect the affluent. Because no chemicals are used, the treated water has no adverse effect on organisms that later consume it, as may be the case with other methods. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement, also need for a highly treated effluent to ensure that the target microorganisms are not shielded from UV radiation like: ifany solids present in the treated effluent may protect microorganisms from UV light.

Septic Tank/Soak-away process: Septic tank is a chamber constructed with concrete, fiberglass or plastics which domestics wastewater flows into for primary treatment and in Nigeria the construction are majorly done with concretes. Settling processes are used to reduce solid and organics and this process are mostly used in rural areas in developed countries but are the most widely practised process in Nigeria, both in the urban and rural areas. The actual treatment process suppose to be that liquid effluent will be disposed in a septic drain field for further treatments. This widely practice contributes to groundwater pollution due to construction process and lack of treatment before disposal.

Construction processes of septic tanks are mainly done with concrete blocks and construction of an open chamber called soak-away pit where the liquid wastewater are been discharged direct to the soil surface without any form of treatment and the solid left in the concrete septic tank .The solid waste will then be evacuated by liquid waste carriers that will discharge them to water source, bury them on the ground, but for some in urban centers like Abuja they normally discharge them into manholes connected to the treatment plant known as WUPA treatment plant.

This unsafe practices contributes highly to our groundwater pollution, the major source of water in the country because most household have there own boreholes that are not properly drilled or with water well that retains water for them during rainy and dry season.

Fig. 2 shows that wastwater is been discharged straight to the soil surface through soak-away process with no treatment which then pollutes the ground water, from Fig. 3 where the soak-away is under construction, you can identify the passage holes and the floor untarred to allow the wastewater to drained direct into the ground soil.

Open surface discharge process: This are the process whereby liquid waste from households are been discharged direct to street roads or drainage system with nothing like treatment, this practice do not only pollute groundwater but degrade the environment with many implications like blocking of the drainage system which pollutes the environment because when the drainage system are blocked the impact will be flooding during raining season and mainly contributes in breeding of rodents and insects, that may result to disease outbreaks like; malaria, typhoid, diarrhea, cholera, Lassa fever and other, and it occurs mostly in low income areas due to their densely population nature and as result of poverty and poor management.

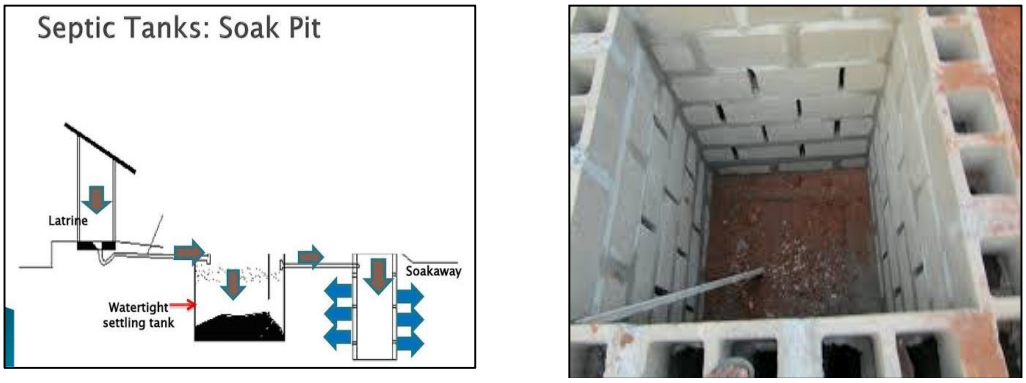

Fig. 2. Schematic and under construction diagram of septic tank and soak-away pit
Source: Slideplayer and Naireland [9,10]

Fig. 3. Wastewater been discharge in open surface

The Fig. 3 shows those low income settlements in Abuja whereby waste are being discharged straight to the surface soil with no proper flow channel. This particular scenes are among major thing that breeds mosquito's and it is found all over the Nigeria cities not only in Abuja, also mostly found in other developing countries that are been contributed by some socioeconomic factors.

These socioeconomic factors contributing to this unsafe practices of waste-water management are: Poverty, Population, Urban planning, Government policies, Awareness, Enforcement.

Poverty: Poverty it is a state or condition in which a person or community lacks the financial resources and essential for minimum standard of living James [11]. From these definition, high number of people in the country lives below one dollar bill and with economic disparity, must cities and community do not have financial power to construct proper liquid waste management plant or to drill an industrial borehole or dams and this pushed citizens to look for other means of survival like drilling of poor quality borehole, water wells and then engage in unsafe wastewater management practices.

Population: This is the total number of individuals occupying an area or makes up whole community, city or country. High population do not have direct impact to underdevelopment but can contribute to the collapse of facility if been over stressed, all the densely populated areas all over the country experience it due to poor infrastructure to accommodate the explosive population increase and they result to difference means of survival by engaging in many unsafe wastewater practices, poor hygiene and others.

Urban planning: According to School of Urban Planning McGill University [12]; it is a technical and political process concerned with control of the use of land and design of the urban environmental, transportation networks and others to ensure orderly development of settlement and community. Some cities in

Nigeria lack proper urban planning, others does but implementation had always been major challenge due to some political differences that contribute to conversion of industrial areas to residential and pushing the average and poor citizens to slumps where must of this unsafe wastewater treatment practices takes place.

Government policies: This a cause of government action, political or business, intended to influence and determine decisions, actions and other matters. Nigeria environmental policies had not been properly implemented and enforced like: indiscriminate drilling of boreholes and construction of wastewater soak-away pit close to each other, a regular practice in many household that serves as their main source of water. This wastewater being discharge to the soil surface contaminates groundwater that can cause serious health effects by contributing to some diseases such as hepatitis, dysentery and others.

Awareness: According to Cambridge [13]; It is state of being of knowledge that something exists or understand the situation, dangers, impacts or subject at a present time based on information. These unsafe liquid waste practices engaged by the populace, most people are not really aware of the environmental and health implications, not because they are not feeling it but they are not been well informed of the dangers.

Enforcement: This is the process of compelling people to comply with already implemented environmental laws. When there is no task force for monitoring and regulation this wastewater management activities, these will result to people engaging in different practices of their choice when there is nothing like monitoring, same with constructions of houses with no approval.

2. MATERIALS AND METHODS

This study was conducted in Abujan federal capital of Nigeria, located in North central with land area of 8,000 square Kilometers. It is bounded on the north by Kaduna state, on the west by Niger state, on the east and south-east by Nasarawa state and on the south-west by Kogi state. It falls within latitude 7 45' and 7 39'. The three type of wastewater management described above are been practiced in different parts of the city but these study is to determine which that is more sustainable to the health, environment and vegetation. Six locations were selected based on the type of wastewater management they engage on, while quantitative and qualitative mode of inquiries was used to explore this wastewater management practices effect to human health and vegetation in this selected areas namely; “Garki, Wuse, Maintaima” highbrow areas and “Lugbe, Kubwa, Nyanya” middle and low middle class area.

Based on primary and secondary source through in-depth interviews and discussion with selected 300 respondents from different household and 50 each from the six locations. Households selected are family residence in highbrow areas and densely populated settlement of low/lower areas with children below 12 years because children are most vulnerable and likely to be exposed to fecal contamination through engagement of outside play. Other information's was accessed through review of relevant texts, journals, newspapers, official publications, magazines and internet which served as tangible source of insight into waste-water management.

In - house survey questionnaire method was employed in the study areas to determine how often the residents with children below 12 years treats malaria and typhoid within 6 months interval, being among sickness contributed by wastewater after effect, there are others like cholera but this two was choose based on survey that they are the most frequently experienced sickness within the study area. The respondents home was visited once in 2 months for the 6 months research period from July to December which covers rainy and dry season for more accurate records from the respondents. The soil samples of the area most effected by the wastewater and less effected in the study environment was analyzed to determine the impact on the soil pH value.

Table 1. Locations name and total number of respondent for each location

Location	Number of respondent
Garki	50
Wuse	50
Maintaima	50
Kubwa	50
Lugbe	50
Nyanya	50

Table 2. Malaria/Typhoid occurrence in 6 months from the study areas (Multiple response)

Number of treatment in six months	Kubwa [Frequency/Total* 100]=%		Nyanya [Frequency/Total* 100]=%		Lugbe [Frequency/Total* 100]=%		Garki [Frequency/Total* 100]=%		Wuse [Frequency/Total* 100]=%		Maitama [Frequency/Total* 100]=%	
	(F)	(%)	(F)	(%)	(F)	(%)	(F)	(%)	(F)	(%)	(F)	(%)
1	-	-	-	-	-	-	18	36%	32	64%	38	76%
2	-	-	-	-	-	-	28	56%	26	52%	12	24%
3	5	10%	3	6%	12	24%	4	8%	2	4%	-	-
4	38	76%	12	24%	26	52%	-	-	-	-	-	-
5	3	6%	32	64%	4	8%	-	-	-	-	-	-
6	4	8%	3	6%	8	16%	-	-	-	-	-	-

Table 1 shows the location and number of respondents from each study areas, residents of Garki, Wuse and Maintaima area connected to sewage treatment plant known as WUPA, while residents of Kubwa, Lugbe and Nyanya engage in soak-away and open surface discharge process.

3. RESULTS AND DISCUSSION

This open discharge of wastewater contaminates groundwater, soil, breeds different insects and rodents that contributes to diseases outbreaks like malaria/typhoid the main focus of these study. The major thing that spreads malaria is mosquito's and their best breeding environment for multiplications are stagnant water, ponds and lakes where they can lay eggs in clumps of within 100 to 300 eggs at once by the corners of this water sauce that they find suitable for aquatic vegetation. This eggs hatches into mosquito's larvae within 48 hours and about a week or 10 days will grow, change to pupa and then turned into adult mosquito within 2 days or more. Typhoid also associated with direct, person to person transmission as a result of improper hygiene, unsafe food and handling of water practice and a study in Kenya shows that cases of typhoid fever among children tend to concentrate in the downstream areas “slums” Adams et al. [14].

Highbrow area “Garki, Wuse, Maitama” and lower income area “Kubwa, Nyanya, Lugbe” were used for the analysis.

Table 2 shows that low/lower class study area Kubwa, Nyanya and Lugbe respondents recorded higher number of treatment in 6 months compare to highbrow areas Garki, Wuse and Maitama. The analysis also shows that some respondents treated both sickness every month in this low/lower class areas. Highbrow study area highest number of treatment record was once or twice in 6 months, like Maitama recorded zero number of 3 treatments in 6months, while Wuse and Garki recorded only 4% and 8% of 3 treatments. Respondents from lower income area had no record of treatment in 1 and 2 within the 6 months of the study, while highbrow respondents also had no record of of treatment on 5 and 6 for these study period.

The analysis shows that residents in lower income of the study area “Kubwa, Nyanya and Lugbe” that engages in open discharge wastewater practice recorded more number of malaria/typhoid treatments more than the highbrow study area “Garki, Wuse and Maitama” that makes use of central sewage treatment plant.

Fig. 4 shows each location with their highest percentage and number of treatments in 6 months and highbrow areas recorded less treatment over low/lower income area. Nyanya recorded more number of treatments, 5 times of 64% in 6 months, Kubwa 4 of 76% and Lugbe with the same number of treatments but different percentage of 52%. Maitama and Wuse with the least number of treatments once in 6 months with different percentage 76% and 64% followed by Garki with twice number of treatments of 56%.

There are also incident of bad odour from this wastewater especially from the open discharge locations of which they are not good for health but residents now see nothing wrong with it anymore because they are use to it.

Analysis shows that wastewater soil from Kubwa, Nyanya and Lugbe pH ranged from 7.56 to 7.45 in soil irrigated with wastewater while Garki, Wuse and Maitama recorded 8.35 to 8.05 because of less impact of wastewater. Soil pH directly affect the life and growth of plants and other green vegetations for it effect the availability of all nutrients in the soil FAO 52, [15]. Between pH of 6.0 and 6.5 high number of plant nutrients are still in their most availability state Pescod et al. [16]. This results also support the explanation that use of wastewater for irrigation purposes can be of detrimental effects to soil quality by decreasing the soil pH and increase the salinity Mutengu et al. *[*17], Kiziloglu et al. [18], Angin et al. [19]. Reduction of pH of soil are cause by acidic components found inside wastewater that then converts to acidic compound which will lead to this reduction of soil pH value and the recommended pH value is less than 8.4.

Table 3. pH level of the study areas

Names	Kubwa	Nyanya	Lugbe	Garki	Wuse	Maintama
pH Level	7.56	7.45	7.53	8.05	8.15	8.35

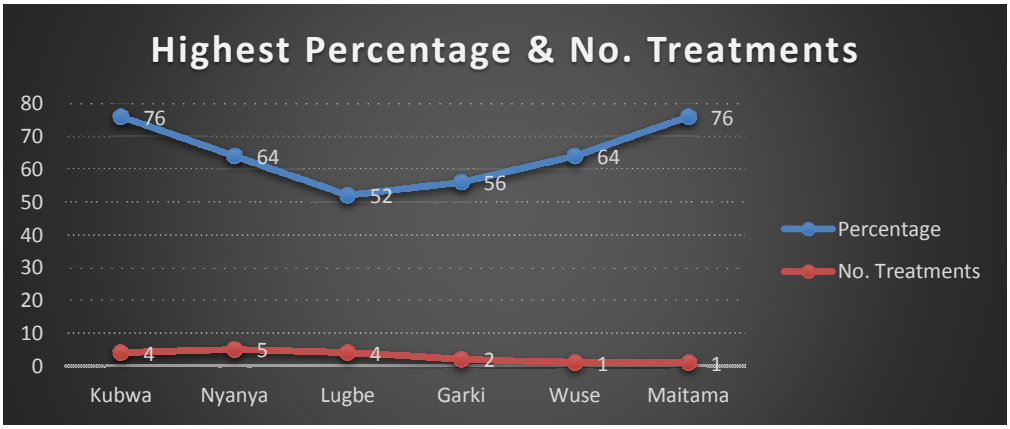

Fig. 4. Highest percentage and number of treatment

This pH analysis gave some insight reason why out of this six study areas three of them, Garki, Wuse and Maitama has more green vegetation compare to the other three Kubwa, Nyanya and Lugbe axis because of different wastewater management being practiced and the three location with less vegetation discharges their wastewater direct on the street with already blocked drainage systems that spill over the street environment and it get worse during rainy season when flash flood will spill it all over the whole area after rainfall. All this finding shows that to achieve sustainable city environment wastewater management is among the key factor that need to be addressed.

4. CONCLUSION AND RECOMMENDATION

Solution to this challenge posed by wastewater to the health and environment on the residents of the study areas rest mainly on government to embark on proper urban planning by providing facilities for wastewater treatment, moreover residents also need to do more by maintaining their surrounding environment, clearing up the water ways and blocked drainage's. There will not be sustainable city environment if there is no proper facilities for it to operate because poor people are most vulnerable to environmental hazards and owing to unequal distribution of assets in the country, they also suffer most from the effects generated by this practices. Findings shows that low/lower income class areas suffer more diseases outbreak because of their densely population with poor amenities and increase in the opportunities for the vulnerable is the only way to sustain overall growth and reduce disparity, disparity on basic amenities like connecting those residents to the central sewage plant most be done drastically so that even if the laws is been enforced, poor people will have alternatives and see reason to keep to the rules and regulations. Government should also collaborate with the estate developers that construct most of this settlements and awareness to the populace by educating them benefits of proper wastewater management and the impacts to their health and the environment.

As a developing nation with enormous economic challenges, we can be able to create a sustainable environmental city with proper utilization of little in our disposal, this wastewater treatment plants if utilized will create jobs, generate revenue through the sale of the hard sludge that will serve as manure for agricultural purpose, reduce contamination and disease outbreak, it will turn to a win win situation for government and the citizens, for a sustainable city environment produces healthy citizens.

CONSENT

As per international standard informed and written participant consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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