

## RAINWATER HARVESTING: POTENTIAL FOR QUALITY LIVING

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**ABSTRACT:** This paper is in support of the solution which has been given due consideration by the government; namely the implementation of rainwater harvesting system. There are many benefits to be derived from rainwater harvesting; not just for users, but also to environment and government. Water is an important element in human life. Our body consists mostly of water. We need water for drinking, cooking, washing, agriculture and to run our industries. We usually take it for granted because of its availability; but when in scarcity it becomes our most precious resource. Even though 70% of our earth is covered with water, 97% of them were the ocean, 2% was glacier and only 1% of this water is fresh. Out of this, 2% is locked in the form of ice and it is only the balance 1% that is being recycling that flow into the lakes and rivers. A United Nation Study published in 1997 indicated that by 2025, the world population will be effected by moderate to severe water shortage. In Malaysia, we are blessed with an ample supply of water because of abundant rains. Normally, we received the rainfall averaging around 2400mm for Peninsular Malaysia, 2360mm for Sabah and 3830mm for Sarawak. However, increasing usage by our industry, agricultural and household users is straining our existing water supply infrastructure. Sandakan was among the early place that did not get enough treated water supply from its water supply authority since 1984. In 1998, the same situation happened in Peninsular of Malaysia. The cost of adding the water supply infrastructures and replacing the ageing systems to avoid this crisis are burdening the government. In order to avoid water crisis as in 1984 and 1998 will not be repeated, a proactive step must be taken to avoid acute water shortage in future.

**Keywords:** rainwater harvesting, rainwater potential, quality living

### 1. INTRODUCTION

Water is important element for all human beings in the world. Our body consists mostly of the water. We need water for drinking, cooking, washing, agriculture and to run our industries. We usually take it for granted because of its availability; but when in scarcity it becomes our most precious resource.

Every raindrop that fall from the cloud is very soft and the cleanest water sources in this world (Texas Water Development Board, 2005a). The falling raindrop acquires slight acidity as it dissolves carbon dioxide and nitrogen (MHLG, 2008). Rainwater is a part of hydrologic cycle; the never-ending exchange of water from the atmosphere to the ocean and back again as in Figure 1. The precipitation like hail, rain, sleet, snow and all the consequently movement of water in nature forms are from part of this cycle.

Rainwater quality always exceeds the surface water and comparable to ground water because of it does not come in contact with soil and rocks where it can dissolve salts and mineral which is harmful for potable and non-potable uses. In the other hands, rainwater is valued for its purity and softness. The rainwater quality usually can be influenced by geographic location, activity in the area and storage tank (Texas Water Development Board, 2005a). However, with minimal treatment and adequate care of the system, rainwater can be used as potable water as well as for irrigation.



Figure 1: Hydrologic Cycle (*Atlas Moden Malaysia dan Dunia, 2003*)

The growth of population and expansion in urbanization, industrialization and irrigated agricultural is imposing growing demand and pressure on water resource. The existing water resources nowadays were facing the pollution because of this phenomenon. A new development of water resource like rainwater is very important to make sure that there is no water shortage in the future. As there will be an ever increasing demand, there is a possibility that the major cities in Malaysia will face a water crisis situation. An approach of rainwater harvesting system into the building is an effective way to minimize the use of treated water for non-potable use.

## 2. RAINWATER HARVESTING SYSTEM

Rainwater can be captured by using the rainwater harvesting system. Generally, rainwater harvesting system is the direct collection of rainwater from roofs and other purpose built catchments, the collection of sheet runoff from man-made ground or natural surface catchments and rock catchments for domestic, industry, agriculture and

environment use. The systems can be categorized as small, medium and large scale (Gould, 1999). Normally, the size of rainwater harvesting was based on the size of catchment area (Thamer *et al.*, 2007).

In scientific term, rainwater harvesting refers to collection and storage of rainwater and also other activities aimed at harvesting surface and groundwater, prevention of losses through evaporation and seepage and all other hydrological studies and engineering interventions, aimed at conservation and efficient utilization of the limited water endowment of physiographic unit as a watershed (Agrawal and Narain, 1999). The category of rainwater harvesting is depicted in Figure 2.

Rainwater harvesting is a traditional practice that dates back hundreds of years. Archeological evidence attests to the capture of rainwater as far as 4,000 years ago and the concept of rainwater harvesting in China may date back 6,000 years (Texas Water Development Board, 2005a). Rainwater has been the main source of water supply for potable and non-potable uses in the old days because the water supply systems were not developing yet. The method of rainwater harvesting at that time was very simple. Usage of the collected water volume from rainwater harvesting was direct and without any treatment. Usually, the rainwater was mostly collected from roofs and some was directly collected (Thamer *et al.*, 2007). Nowadays, the responsibility rests on the State Water Board to operate and runs water supply for residential areas and commercial. With this, rainwater harvesting system has been ignored.

Rainwater harvesting system has been implemented in many countries such as USA, Japan, China, India, Germany and Australia to support the increasing water demand. The integration between rainwater harvesting system and existing conventional water supply systems will help to meet the demand and contribute in the sustainability of the water supply.

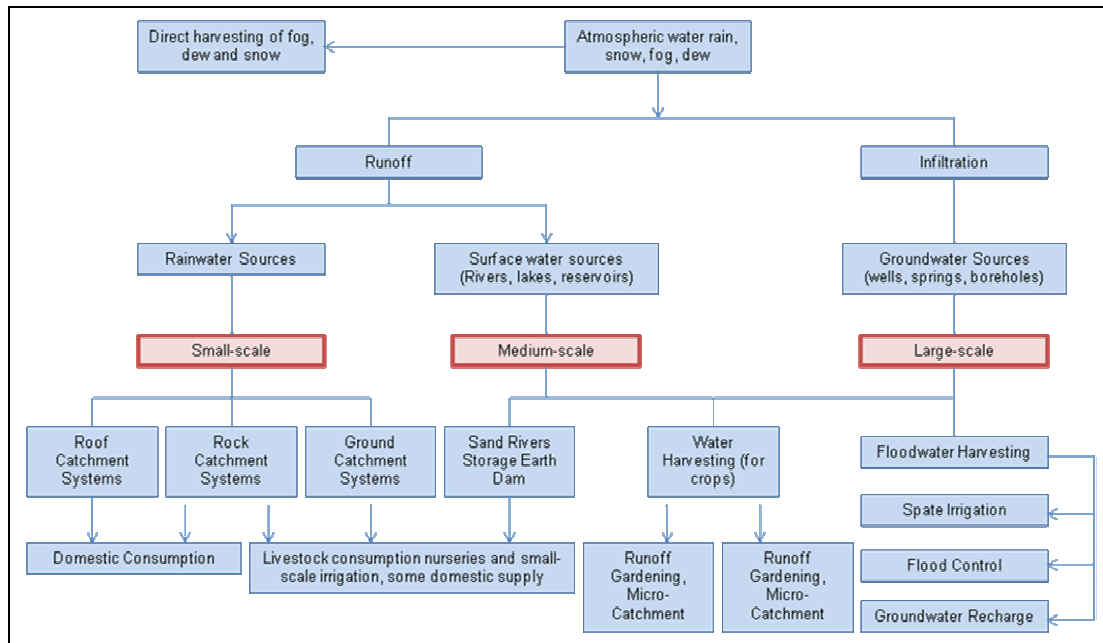


Figure 2: Rainwater Harvesting Category (Ahmad Jamalluddin and Huang Yuk Feng, NAHRIM)

There are six main elements in rainwater harvesting system as in Table 1. They are catchment area, gutter and downspout, filtration system, storage system, delivery system and treatment.

Table 1: Elements of Rainwater Harvesting System (Texas Water Development Board, 2005a)

No.	Elements of Rainwater Harvesting System	Description
1	Catchment surface	The collection surface from which rainfall runs off
2	Gutter and downspout	Channel water from the roof to the tank
3	Filtration: Leaf screens, first flush diverters and roof washer	Component which remove debris and dust from the captured rainwater before it goes to the tank
4	Storage tank	Also known as cisterns
5	Delivery system	There are two type of delivery system; gravity-fed or pumped to the end use
6	Treatment/purification	For potable systems, filters and other methods to make the water safe to drink

### 3. WATER SHORTAGE IN MALAYSIA

The Malaysian economy has gone through rapid structural change since independence in 1957. In global arena, Malaysia is often considered as a ‘develop’ country. The urban growth is dynamic in accordance with the rapid economic growth and industrialization.

The infrastructure has been strained by rapid urban growth and there are high needs of improvement of amenities such as water supply, electricity, transportation, environment and drainage (Weng *et al.*, nd). The impacts of the growth have put excessive demands on water supply and water resources. Besides economy and industrialization, the number of population also has increase. Malaysia has a few cities with high density of population such as Lembah Klang, Pulau Pinang and Johor Bahru. These cities required more demands on water supply than other cities in Malaysia.

In 1998, Malaysia facing the serious water crisis because of the drought from climate changes (El Nino Phenomena) and as shown in Figure 3. Due to this, Lembah Klang is one of the top critical places having the water crisis. The State Water Board has to ratio all the water supply to make sure the entire user get enough water at that time. Government has listed some of the effort that can be used for water shortage; rainwater harvesting system is a part of it (Mohd.-Shawahid *et al.*, 2007). However, the implementation of this system is not moving further because of lack awareness among the users at that time (Mohd.-Shawahid *et al.*, 2007).



Figure 3: News on water crisis in 1998 (Berita Harian)

Malaysia has more than 95 percent coverage of piped water in rural areas and 99 percent for urban areas which unfortunately stop the development of rainwater harvesting system (Weng *et al.*, nd). However, it is not the main factor that makes this issue happened. There are a lot of reasons why rainwater harvesting system can not be successfully developed in Malaysia. Table 2 shows some of the reason. Most of all, the traditional drainage manual of 1975 encourages maximum drainage rather than retaining rainwater (Weng *et al.*, nd).

Table 2: Development of Rainwater Harvesting System Inhibit Factors (Weng *et al.*, nd).

<b>Development of Rainwater Harvesting System Inhibit Factors</b>
<ul style="list-style-type: none"> <li>• The rich water resource base due to copious rainfall</li> <li>• Frequent flooding that give the impression that is unnecessary to harvest rainfall</li> <li>• A single approach of Water Demand Management (WDM) based on construction of dams, treatment plants and supply mains</li> <li>• Low water tariffs making it uneconomical to install rainwater mechanisms</li> <li>• Lack of incentives to include rainwater harvesting in building design</li> <li>• Lack of mandatory regulation to enforce rainwater harvesting system</li> </ul>

#### **4. IMPLEMENTATION OF RAINWATER HARVESTING SYSTEM IN MALAYSIA**

Rainwater harvesting system was introduced after the 1998 drought by Ministry of Housing and Local Government (MHLG). The 1999 'Guidelines for Installing a Rainwater Collection and Utilization System' can be seen as the initial phase of the rainwater harvesting policy in Malaysia. The main purpose of this guidelines is to reduce the dependence on treated water and provides a convenient buffer in times of emergency or a shortfall in the water supply. It also proposed the construction of 'mini dams' or rainwater tanks in urban area instead of continuing to build giant dams upstream (Mohd.-Shawahid *et al.*, 2007). This guidelines is intended as an 'ideal manual' for reference for those who want to install a rainwater harvesting and utilization system (MHLG, 2008)

After five years of this guidelines, namely in 2004, the Ministry of Housing and Local Government has prepared another cabinet paper to the National Water Resources Council to encourage government buildings to install a rainwater collection and utilization system. The Council has later announced that rainwater utilization is to be encouraged, but not mandatory. The Department of Irrigation and Drainage and The Ministry of Energy, Water and Communication (KTAK) are the two government agencies that implement the rainwater harvesting system in the early. The acceptance on rainwater harvesting system in the beginning is not good enough. Only few areas like Sandakan and Shah Alam that has introduced rainwater harvesting system in new housing developments (Mohd.-Shawahid *et al.*, 2007).

National Hydraulic Research Institute of Malaysia (NAHRIM) was established under Ministry of Natural Resources and Environment in 2004 is also one of the agencies that carried out pilot projects for rainwater harvesting system. The projects are (i) double storey terrace house located at Taman Wangsa Melawati, Kuala Lumpur, (ii)

Taman Bukit Indah Mosque, Ampang and (iii) Headquarters of the Department of Irrigation and Drainage, Kuala Lumpur (Jamaluddin and Huang, 2007). In support of the Government's interest in Rainwater harvesting system, NAHRIM also actively involved in designing and installing rainwater harvesting system for several schools (Mohd.-Shawahid *et al.*, 2007).

In 2005, the Federal Constitution has been transferred all matters related to water supply services from State List to Concurrent List (Mohd.-Shawahid, *et. al.* 2007). This enable the Federal Government involvement in the water services sector and to establish regulated water services industry. Due to this, Ministry of Energy, Water and Telecommunication (KTAK) has come up with two new water related laws; Water Services Industry Act 2006 and Water Services Commission Act 2006. In the new act, the Ministry is actively involved in the water saving programs which encouraging rainwater harvesting system implementation.

## **5. POTENTIAL FOR LIVING QUALITY**

Extreme climate events such as drought and flood happened frequently nowadays because of the global weather change. This event affected the water resources utilization for various purposes. As a result, many countries adopting strategies to conserve the available water resources including promoting the usage of rainwater harvesting system for landscaping and agricultural (Thamer *et al.*, 2007).

Malaysia receives plenty of rainfall throughout the year and because of that Malaysia experiences a wet equatorial climate regime. In fact, there is no distinct dry season in any part of the country (Weng *et al.*, nd). Malaysia has an average rainfall around 3,000 mm a year - Peninsular Malaysia averaging 2,420 mm; Sabah averaging 2,630 mm and Sarawak averaging 3,830 mm (Salmah and Rafidah, 1999). Figure 4 show the average rainfall pattern since 1997 to 2007.

The main rainy season in the east runs between November and February, while August is the wettest period on the west coast. East Malaysia has heavy rains (November to February) in Sabah and in Sarawak. Based on an average annual rainfall of about 3,000 mm per year, Malaysia is endowed with an estimated total annual water resource of some 990 billion cubic meters (BCM) which is one BCM is equal to one million mega liters (Keizrul, 2002).

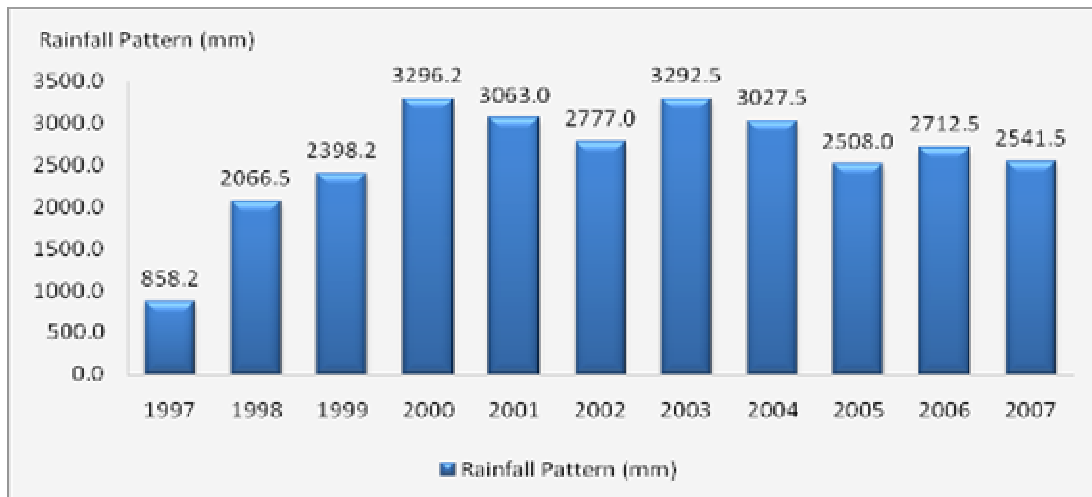


Figure 4: Rainfall Pattern (Department of Irrigation and Drainage, 2008)

Presently, the existing water supply systems have improved but the demand is increasing due to the population growth and expansion in urbanization, industrialization and irrigated agricultural. The prolonged dry period due to global weather change can be considered as another factor effecting water supply. The available water resources are limited and/or seasonal which made the experts working in the water sector to search for solution to the water shortage (Thamer *et al.*, 2007). A systematic support to local innovations on rainwater harvesting could provide substantial amounts of water and reduce demand on water supply systems.

Rainwater has a lot of potential as main water resource for the future because of its high quality (Texas Water Development Board, 2005a). Every raindrop acquires slight acidity as it dissolves carbon dioxide and nitrogen from air pollutants (Texas Water Development Board, 2005a; MHLG, 2008). Usually, contaminants captured by rain from the catchment surface and storage tanks. The catchment areas may have dust, dirt, animals fecal and plant debris such as leaves and twigs. Simple treatment such as filtration and disinfection equipment can be used to improve the quality of rainwater. There are five factors affecting the rainwater quality; (i) pH, (ii) particulate matter, (iii) chemical compounds, (iv) catchment surface and (v) tanks (Texas Water Development Board, 2005a).

In many urban and industrial areas in Malaysia, the pH of the rainwater is often less than 4.5 (Weng *et al.*, 2004). Another study by NAHRIM in Malaysia showed that most water quality parameters of rainwater are within the WHO guidelines for drinking water except *Coliform* as shown in Table 3 (Rozman, 2006). Result still showed that



rainwater quality was good and comparable to piped water in another NAHRIM's study by Ahmad Jamaluddin Shaaban as shown in Table 4. In some parameters, rainwater has better quality than piped water.

Table 3: Water Quality of Rainwater (Rozman, 2006)

Parameter	Unit	Rainwater harvested in polyvinyl tanks	WHO drinking water guideline standard
pH	mg/l	6.0	6.5 – 6.8
Sulfate	mg/l	0	250
Chloride	mg/l	<0.3	250
Iron	mg/l	0.2	0.3
Nitrate	mg/l	0.5	50
Coliform Count	Count/100ml	1-27	0

Table 4: Rainwater and Piped Water Quality (Jamaluddin, 1999 in Weng; et. al. 2004)

Parameter	Open Rain	Rain from Roof Tiles	Rain from Metal Roof	Water from Main Pipes	Piped Water from Water Tank	Water from Water Cooler	Rain from Concrete Tank	WHO Guideline
Cadmium	<0.001	<0.001-0.001	<0.001-0.002	<0.001	<0.001	<0.001	nd	0.03
Chloride	0.7–1.6	0.3-0.9	0.7-1.2	3.6-4.6	4.3-4.5	5.1	<0.3	250
Iron	0.09-1.02	0.01-0.05	0.11-0.29	0.04-1.35	0.33-1.72	0.15	0.2	0.3
Lead	<0.01-0.02	<0.01-0.05	<0.01-0.02	<0.01	<0.001	0.02	nd	0.01
Manganese	0.001-0.042	0.001-0.02	0.006-0.015	0.015-0.047	0.012-0.03	0.007	0	0.1-0.5
Nitrate	0.32-1.45	0.84-2.05	0.78-1.75	0.43-1.02	0.22-0.84	0.44	nd	50
pH	3.47-6.47	6.12-7.72	3.91-5.41	7.4-8.38	7.22-8.47	8.01	5.82	6.5-8.5
Solids, Total Dissolved	16-32	16-43	11-21	39-48	38-54	48	nd	1000
Sulfate	1-15	0-16	-	13-17	10-19	17	0	250

Rainwater can be used for potable and non-potable uses as in Table 5. With high quality and minimal treatment, rainwater will help the user to meet their demand for the quality living in the future.

Table 5: Rainwater Uses

Potable Uses	Non-potable Uses
<ul style="list-style-type: none"> <li>• Drinking</li> <li>• Bathing</li> <li>• Cooking</li> <li>• Dish wash</li> </ul>	<ul style="list-style-type: none"> <li>• Flushing toilet</li> <li>• Watering garden</li> <li>• General cleaning</li> </ul>
Rainwater must be treated to remove contaminants	Treatment of rainwater is not required

According to NAHRIM's research, 34 percent of collected rainwater has been used by household of six people (two adults and four school going children) for non-potable purpose per month. It means that 34 percent of treated water has been saving from non-potable use per month. As a result, the water bill also can be reduced.

Table 6: Rainwater Uses for Household of six (Jamaluddin and Appan, 2003)

Rainwater Uses	Average Daily Use (litres)	Average Monthly Use (litres)
Washing Clothes	300	9,000
Toilet Flushing (3 WCs)	90	2,700
General Cleaning (including car and motorcycle washing)	65	1,950
<b>Total</b>	<b>455</b>	<b>13,650</b>

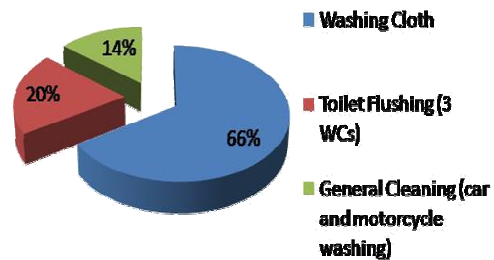


Figure 5: Percentages of Rainwater Use for Various Facilities (Jamaluddin and Appan, 2003)

In Sandakan, the rainwater harvesting approach had satisfying exceeds the people demand on water resource (Sandakan Municipal Council, 2008). They are using rainwater for all the non-potable uses. Sandakan is the early place that did not get enough treated water supply from State Water Board in Malaysia since 1984. The scarcity of water due to the rationing (around twice a week) from State Water Board has made them aware of the important of rainwater harvesting system as an alternative water supply (Sandakan Municipal Council, 2008). Besides, almost all of the water has been use for non-potable. By using rainwater, they can minimize the usage amount of treated water for non-potable uses. This situation proved that by using rainwater a lot of saving can be done and will improve living quality.

Besides for housing scheme, rainwater can be use for irrigation. Furthermore, if native and desert-adapted plants are used for landscaping, rainwater harvesting becomes effective tool for water conservation (Thamer *et al.*, 2007). By using rainwater harvesting system, the provided irrigation water is not taken from storage allocated for municipal water supply. This situation can reduce groundwater exploitation, flooding, to control erosion and to improve water quality by holding storm runoff on the site (on site detention), and cost reduction (Thamer *et al.*, 2007).

Rainwater is a clean source of water for plants (free from salt). As a result, rainwater harvesting can reduce salt accumulation and contribute in a good soil environment for root growth. The salt concentration in root zone of the plants is reduced when collected rainwater percolates deep into the soil and diluting available salt in this zone. This will result in greater root growth and water uptake which increases the drought tolerance of plants. Limitations of rainwater harvesting are few and easily met by good planning and design (Thamer *et al.*, 2007).

## 6. BENEFITS OF RAINWATER HARVESTING SYSTEM

Rainwater harvesting is part of sustainable architecture and it is bring a lot of advantages; not just for users but also to environment and government. In short, Table 7 shows some of the benefits from rainwater harvesting system.

*Table 7: Benefits of rainwater harvesting to users, environment and government*

Users	Environment	Government
<ul style="list-style-type: none"> <li>• Independent and ample water supply</li> <li>• Save money by reducing the volume of water purchased from public systems</li> <li>• Save money by extending the life of plumbing fixtures and appliances</li> <li>• Avoid interrupted service from centralized water systems or overuse of water from a well</li> </ul>	<ul style="list-style-type: none"> <li>• By capturing rainwater, we reduce the abundant amount of rainwater that goes to the drainage and avoiding the floods phenomena</li> <li>• We can significantly reduce our reliance on water storage dam. This will avoids ecological damage to the area which has to be submerged to build the dam.</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce the burden for new investment to replace the ageing systems and adding the water supply infrastructures</li> <li>• Potentially avoid the cost of accessing public water systems when it is not economically feasible</li> </ul>

## 7. CONCLUSION

Demand on water resources has increase day by day due to the population growth and expansion in urbanization, industrialization and irrigated agricultural. Adopting the concept of sustainability and conservation of water resources can help to cope with the global water shortage. Rainwater harvesting system is one of the concepts that can be implemented to meet the water shortage problem. The quantity and quality of rainwater collected is different from place to place depending on the weather, geographic

location, activity in the area and storage tank. Furthermore, rainwater has a lot of potential as an alternative water resource for the future because of its high quality. Rainwater quality always exceeds the surface water and comparable to ground water because of it does not come in contact with soil and rocks where it can dissolve salts and mineral which is harmful for potable and non-potable uses. Sandakan Municipal Council has prove that rainwater harvesting system improve Sandakan's people quality of living. Successful implementation of rainwater harvesting system at Sandakan is a great contribution for future rainwater harvesting development and living quality. Government agencies are play an important role to promote the practice like offering incentives for fees of concerned authorities.

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