Groundwater resources in Sri Lanka and its importance towards economic development

Abstract

Goundwater identified as an economic resource has a great potential to enhance productivity in agricultural and industrial sectors. In addition, use of groundwater as a safe drinking water for drinking purposes has great influence to improve human health and in turn enhance the socio – economic situation of the country. Due to limited water resources available in rivers, lakes etc, use of groundwater being gradually increased as a major source for many urban water supplies mainly for Industrial and domestic purposes . Groundwater was the only sources for water supplies in accelerated development projects implemented in recent past which gave enormous contribution to the economic development of the country. In rural areas groundwater is used in rural farming and drinking purposes. Abstraction of groundwater by means of ***Agro-wells*** *(shallow open wells) and* ***deep tube wells*** *increase the productivity of the rural farming activities, specially in dry zone of Sri Lanka.*

From these facts , link between use of groundwater and economic development , social welfare have to be accepted without any doubts. However, intensive groundwater development may induce some negative effects such as groundwater level and storage depletion, saline water intrusion in coastal areas and sometimes deterioration of water quality. Therefore, systematic groundwater exploration and development is required to sustain the limited water resources in the country.

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Introduction

What is groundwater ?

Groundwater is that portion of the water beneath the surface of the earth that can be collected with wells or that flows naturally to the earth surface via seeps or springs.

How ground water occurs in rocks

It is difficult to visualize water in underground. Some believe that ground water collects in underground lakes or flows through underground rivers. In fact, ground water is simply the subsurface water that fully saturates pores or cracks in soils and rocks. Ground water is replenished by precipitation and, depending on the local climate and geology, is unevenly distributed in both quantity and quality. When rain falls or snow melts, some of the water evaporates, some is transpired by plants, some flows overland and collects in streams, and some infiltrates into the pores or cracks of the soil and rocks and move further downwards to reach the water table.

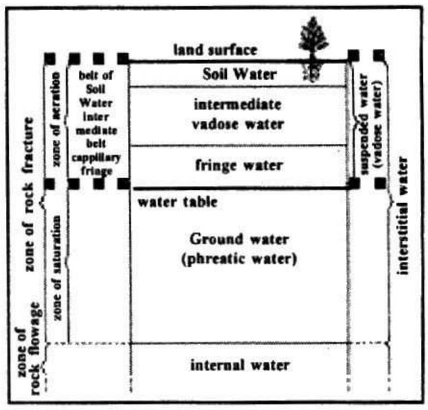


Figure 2 : Diagram showing divisions of subsurface water (from O. E. Meinzer)

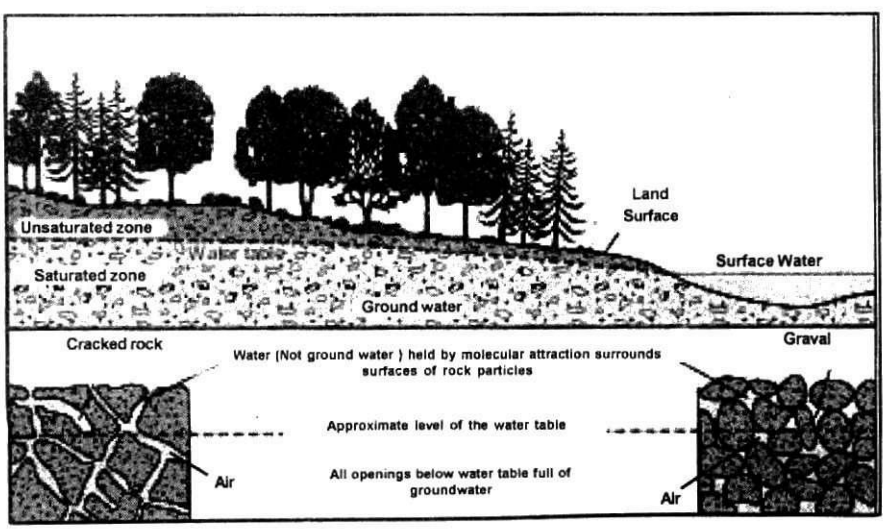


Figure 1 : How groundwater occurs in rocks

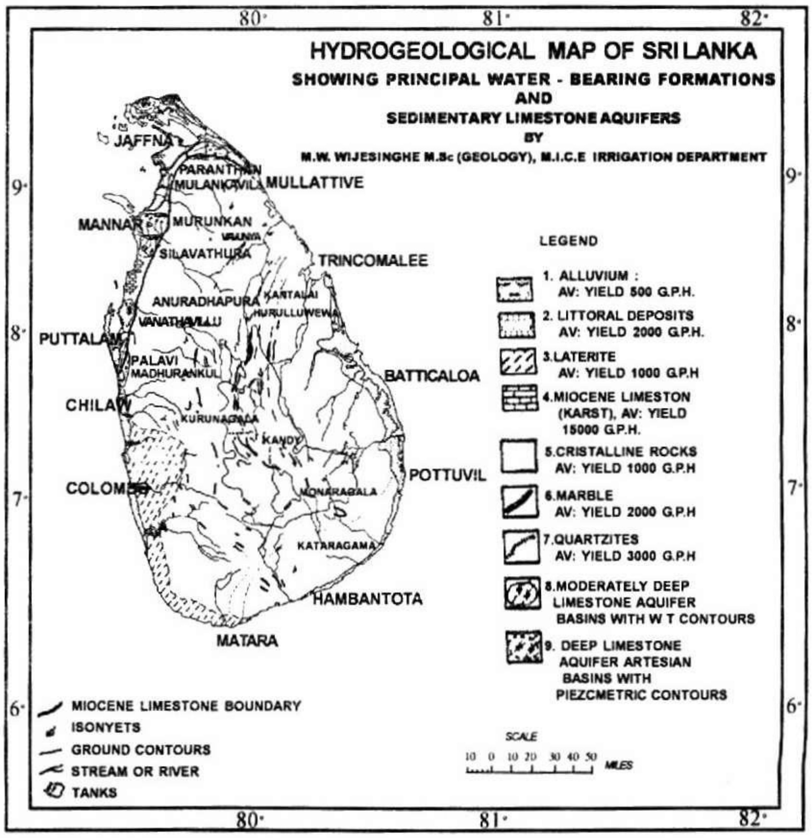
Principles of groundwater occurrence and movements

As a starting point, it is intended to provide some basics of groundwater to assist redears who do not have background knowledge of this decipline. Therefore, the following discussion of the occurrence of ground water has been adapted from Meinzer (1923) to explain groundwater occurrence and its flow characteristics.

The rocks that make up the crust of the earth generally are not solid, but have many openings, called **voids or interstices**, which may contain air, natural gas, oil, or water. The many different kinds of rocks differ greatly in the number, size, shape, and arrangement of their interstices; therefore, the occurrence of water in any region is determined by the geology of the region.

The interstices or voids in rocks range in size from microscopic openings to the huge caverns found in some limestones. The porosity of a rock is expressed quantitatively as the percentage of the total volume of the rock that is occupied by interstices or that is not occupied by solid rock material. Uncemented gravel deposits having a uniform grain size have a high porosity, whereas deposits made up of a mixture of sand, clay, and gravel may have a very low porosity because the smaller particles occupy the space between adjacent large particles. Relatively soluble rock such as limestone, though originally dense, may become cavernous as a result of the removal of part of its substance through the solvent action of percolating water. Hard, brittle rock may acquire large interstices through **fracturing** that results from shrinkage or **deformation** of the rocks or through other agencies.

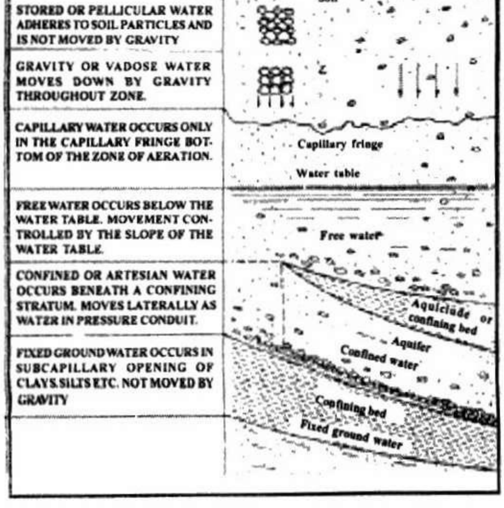
Figure 4 : Major hydrogeological regions of Sri Lanka (Cooray 1984)



The **permeability** of a rock is its capacity for transmitting water under pressure and is measured by the rate at which the rock will transmit water through a given cross section under a given difference of head per unit of distance. A rock containing many very small interstices may be porous, but not very permeable; whereas, a coarser-grained rock may have a low porosity but will generally be much more permeable.

The permeable rocks that lie below a certain level are generally saturated with water under hydrostatic pressure. These saturated rocks are said to be in the zone of saturation (Figure 2). The zone of saturation ordinarily extends down to a depth much greater than is reached by modern drilling methods. The term ground water is also used to designate that part of the subsurface water within the zone of saturation. The upper surface of the zone of saturation when not formed by an impermeable body is called the ground-water table, or simply, the water table. In most places there is only one zone of saturation, but in certain localities the water may be hindered in its downward course by an impermeable or nearly impermeable bed to such an extent that it forms an upper zone of saturation, or **perched** water body, that is not associated with the lower zone of saturation. Figure 3 shows field situation of movement of groundwater in vertical soil profile with various aquifer types which are important in storing water (Chatterjee 1994)

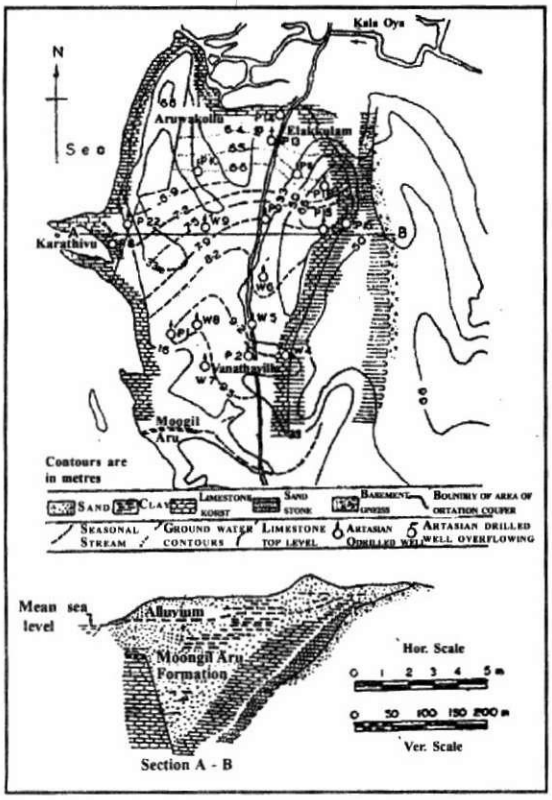
Figure 3 : Soil profile with different aquifers



Aquifer: A subsurface zone that yields economically important amounts of water to wells. The term is synonymous with water-bearing formation. An aquifer may be a porous rock, unconsolidated gravel, fractured rock, or cavernous limestone. Aquifers are important reservoirs storing large amounts of water relatively free from evaporation loss or **pollution.**

Aquitard is a geological formation that may contain groundwater but is not capable of transmitting significant quantities of it under normal hydraulic gradients. It may function as confining bed. **Aquiclude** is a geological formation not capable of transmitting water.

Figure 5 : Vanathavillu basin (Wijesinghe 1973)



Groundwater Occurrences in Sri Lanka and development capabilities for economic development

In this brief description it is intended to provide general groundwater condition with its development possibility for economic development. Major groundwater regions (see figure 4) and aquifer basins summarized in the following chapter :

1.North and Nortwest Limestone Belt

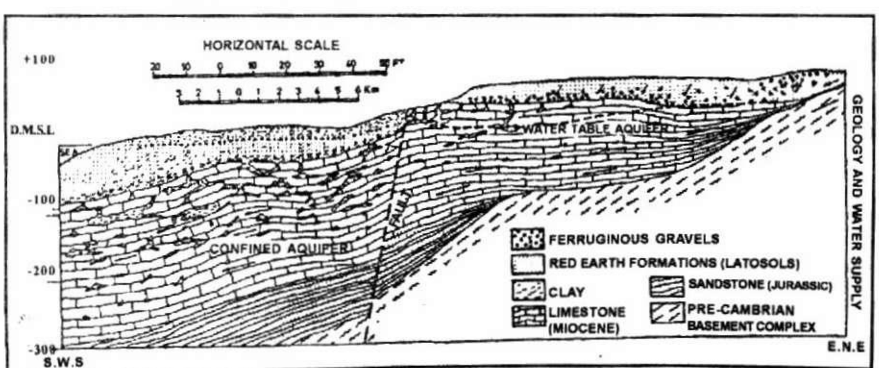
This is the main sedimentary basin of the country and confined to the Northwestern coastal belt extending from Mundal area, South of Puttalam, to the extreme North encompassing the Jaffna peninsula. This is one of the richest groundwater basin in the country with good quality water at varying depths with artesian conditions as showing in Figure 4.

The Vanathavillu Basin

The total thickness of sedimentary formations vary from 50 feet in the East and increasing about 800 feet towards the West. This is shown in Figure 5. Hydrogeologically this has both free water table and artesian aquifer characteristics.

According to the available data on deep tube wells drilled from 100 - 150 meters depth, safe yield of 20 - 35 gallons per minute with good quality water. Presently more than 100 deep wells have been constructed for agriculture and prawn culture purposes . Based on the findings of previous studies (Wijesinghe,1973) nearly 1200 acres of land could be brought under successful agriculture crops and further development is possible .

Figure 6 . Geological condition of Murunkan basin



GEOLOGIC SECTION ACROSS THE MURUKAN BASIN

Geological cross-section across the Murunkan Basin showing groundwater conditions in confined aquifer in limestone.

(After M. W. P. Wijesinghe, 1977)

Murunkan - Silavatura Basin

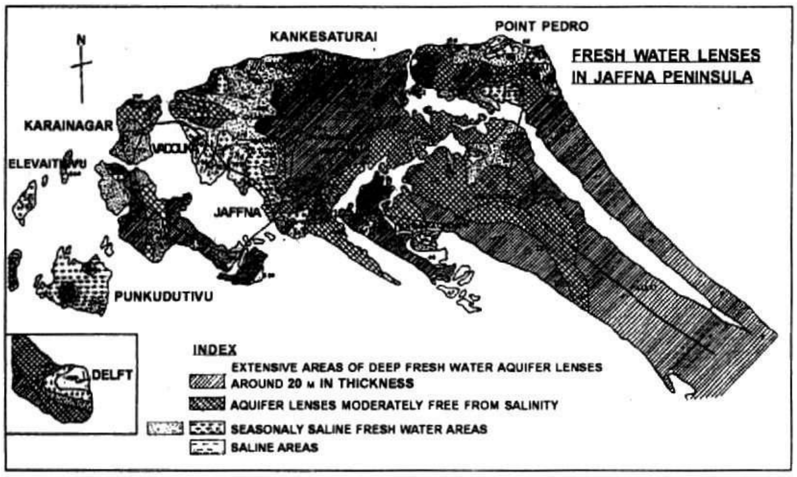
This basin covers 310 sq km area and it has similar geological characteristics as in the Vanathavillu basin consisting of Jurrasic sandstone, karst Miocene limestone and quaternary unconsolidated sediments (Fig 6).This is essentially water table aquifer with water table being 10 - 20 meters below the ground level.

The water Quality is very high having an average salinity of 200 ppm. Well yield varies from 10 -15 litre per seconds satisfactory for irrigating agriculture fields. Safe groundwater abstraction limit identified by previous studies (Herbet et al ,1988) was 4-5 Million Cubic Meters (MCM) per annuam and can be used for development activities mainly towards agriculture development Within the Murunkan and Mannar area, groundwater is used to supplement the surface water supply using Giant's Tank for the irrigation of rice fields. Previous studies concluded that potable groundwater can be obtained from the top most zone of the aquifer at a depth of 20 meters below sea level and a further deeper zone contain very saline water.

Jaffna Penninsula

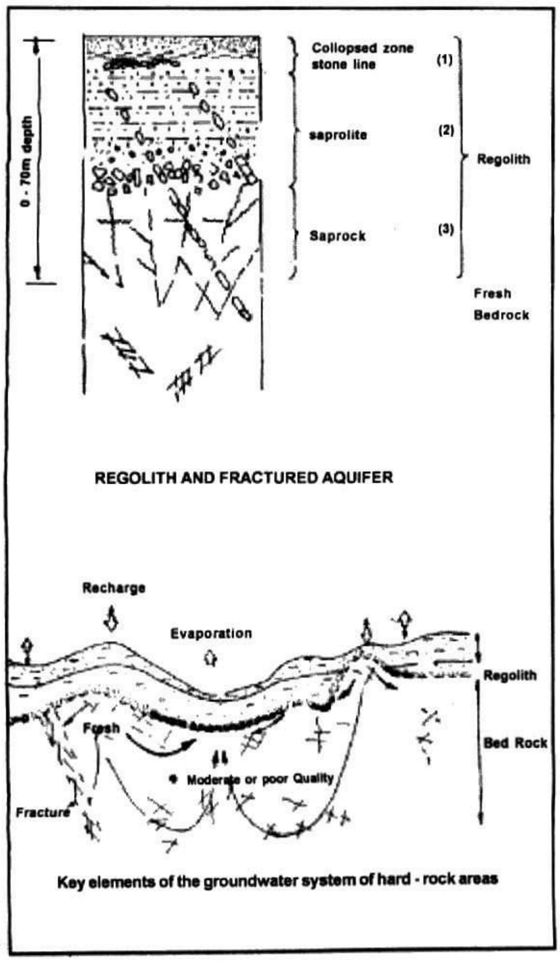
Groundwater in Jaffna in highly cavernous (karst) limestone formations that lie within shallow depth in most part of the area. Due to the dense network of caverns, fractures and fissures, the entire peninsula is subjected to sea water intrusion but, supports accumulation of freshwater mounds in the central part of the land units. Average groundwater recharge from seasonal rainfall have been evaluated over 10 years and usable groundwater has been evaluated roughly ranging between 10 - 25 MCM. Recent studies conducted (Wijesinghe 2002) in the area have indicated thickness of fresh water lens ranging from 20 - 30 meters in Putur, Pannikkudduwan and Uralli -

Figure 7 : Groundwater situation in Jaffna



Pokkanai areas . It has also found that productive groundwater lenses that covers a total area around 25 sq km extending up to Thirunaweli in the South and up to Vasavillan to the North. The updated map is shown in Figure 7.

More productive soils (red soils) occupy the major inland portions and crops originally cultivated are chillies, onions, potatoes, tobacco, vegetables, bananas, these crops are cultivated throughout the dry season using groundwater irrigation contributing to our national economy. Due to intensive agriculture , high nitrate levels were found and therefore, proper management is needed to prevent such pollutions. Therefore, it is essential to undertake detail groundwater assessment to evaluate quantity and quality prior to implement new agriculture development projects.



Coastal Sand Deposit and River Alluvial Deposits

This aquifer systems also identified as a large carrier of groundwater.

Coastal sands: Three main types have been recognized (Panabokke et al 2002)

1. Shallow aquifers coastal spits and bars occupied in Kalpitiya, Poonaryn and Mannar Island

2. Shallow aquifers on raised beaches located in Pulmude, Nilaveli Kalkudah and Hambantota

3. Moderately deep aquifers on old red and yellow sands locted in Katunayake and Chillaw

In these aquifers groundwater could be developed from shallow tube wells up to depth of 30 m for agricultural and industrial purposes with capacities ranging from 5 -10 liters per second per well. For example , Free Trade Zone at Katunayaka, nearly 1 million gallons of water per day was developed by means of tube wells in early 1990 and it is still being expanded with industrial development. Koggala free trade zone is another example as groundwater was the only water source when it was started.

River alluvial deposits : River alluvial deposits are extensive in flood plains specially in river out-fall areas. Groundwater potential is very high in these aquifers and water could be tapped continuously for industrial and agriculture purposes. Major alluvial basins are associated with Mahaweli , Kelani, Kalu , Walave and Kirindi oya river basins.

Groundwater in Crystalline rocks

Nearly nine-tenths of Sri Lanka is underlain by crystalline rocks which is also called **Hard Rocks (Figure 4).** Granites, Quartzites , Charnockites , Marble (crystalline limestone) and Gneisses are common hard rocks in Sri Lanka. In previous studies (Herbet et al 1988) groundwater occurrence in weathered rock and soil overburden has been defined as **Regolith** aquifer (Figure 8) and below this a zone of fractures developed due to various deformations occurred in geological history. Development of fractures in crystalline hard rocks is mainly due to occurrences of tectonic events in geological history. These fractures are formed by geo-structures such as joints, faults , contact zones between different brocks and shear zones as these **week zones** have some open spaces capable of storing and transmitting water. Figure 9 shows generalized groundwater flow characteristics in fractured aquifer.

Shallow Regolith Aquifer

Many agrowells (large diameter open dugwells) have been constructed mainly in regolith aquifer penetrating to the top of the saprock. Some students (Panabokke; et al 2002) identified occurrence of fevourable groundwater condition for agrowells in small tank cascade in Northcentral and Northwestern provinces . This productive groundwater zone is located mainly in saprolite (Figure 8) which include highly weathered and moderately fractured rock materials and some localities it has slightly weathered rock with open joints. It is reported that (Panabokke; et al 2002) 100 mm of groundwater recharge in upland areas and 150 mm in lowland paddy areas. Since these figures refer to the tank cascade system of Northwestern and Northcentral provinces of the country, it reveals possibility of development of agro-wells to increase agricultural land area specially in dry seasons where surface water irrigation by small tanks are not sufficient. A methodology also developed (Senaratne 1996) to allocation of agro-wells in a tank cascade system to optimize groundwater abstraction by means of agro-wells.

Deep fractured aquifer system

Groundwater abstraction in deep fractured aquifers is possible by means of tube wells having depth varying from 30 - 100 meters. Data on tube wells drilled so far in the country, well yields varies from 5 - 200 liters per minute, in general, but much higher yield have been observed under special hydrogeological situations. Low yielding tube wells (yield less than 5 litres per minute) can be used for rural water supplies using hand pumps and high yielding tube wells (yield not less than 20 liter per minute) can be considered as production wells and suitable for development of agriculturel, industrial and domestic water supply schemes using electro submersible pumps. In late 1980s more than 100 individual water supplies have been implemented (by abstracting groundwater from fractured aquifers) for garment factories. Intakes for water supply for Vavuniya town is fully met by deep fractures aquifer. In addition , several urban water supplies are now being augmented by deep fractured groundwater.

South-western Laterite Region Aquifer

Laterite is a product of decomposition of crystalline rock occurs in Southwest region . Since the area is densely populated with increased industrial activities groundwater in Laterite aquifer is important for economic development. Reported well yields in Ragama area (Cooray 1984) 60,000 gallons per day (from 11 wells) and Gonitota a single well yields 80,000 gallons per day. The variation is due to filling of kaolin clay in permeable zone.The rapid development of industrial zones and urban housing schemes that are taken place in the area are excerting tremendous pressure on this groundwater resource. Therefore further groundwater development to be carefully undertaken after carrying out systematic groundwater exploration and groundwater monitoring net work should be developed to study the impact of long term ground water abstraction .

Conclusion

Use of groundwater for urban and municipal water supplies, industrial and agriculture sector play a main role in socio-economic development in the country. Detail assessment of groundwater resources should be carried out to understand the possibility of optimum use of groundwater for further development. Since groundwater pollution and water level depletion have been reported in some areas, attention has to be paid on groundwater conservation measures. In this regard a separate Institution for groundwater development and management is essential and its functional domain should be integrated with other agencies engaged in surface water , soil and land use, forestry, industrial and agriculture sectors. Community participation in groundwater management has to be further improved for effective and efficient development of limited groundwater resources.

References :

Wijesinghe, M.W.P., 1973*: ground water hydrology. In: "research in Earth Sciences, Forestry and Fisheries" , Ceylon Association for the advancement of Science Symposium , Colombo 1973.*

Wijesinghe, M.W.P.*, 2003: Occurrence ground water resources in Jaffna Peninsula – Water Resources Board.*

Kodituwakku, K. A. W. *, 1985: Groundwater Explorations in Anuradhapura Dry Zone agricultural Development Project, Water Resources Board.*

Cooray, P. G. 1988*: The geology of Sri Lanka , National Museum, Colombo.*

Herbet, R. , Ball, D. F. , Rodrigo, I. W. and Wright , E. P. *, 1988: the regolith aquifer of hard rock areas and its exploration with references to Sri Lanka . Journal of Geological Society of Sri Lanka.*

Senerathna, A. *(1996) consultant's Report to IIMI on Ground water in the North Central Province.*

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