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Assessment of water quality of lake Hyqe, South Wollo, Ethiopia

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Abstract
The physical and chemical properties of water bodies are characteristics of climate, geochemical, geomorphological and pollution conditions (largely) prevailing in the drainage basin and the underlying aquifer. The availability of good water is an understandable feature for preventing disease and improves quality of life. The present study investigation of the water quality Lake Haque has been carried out. To assess the status water samples were collected in monthly intervals for the period of one year. Depending on seasonal variations the intervals are divided accordingly into dry period (January to April) and wet season (July to October). Various physio- chemical parameters such as pH, temperature, turbidity, dissolved oxygen (DO), nitrate, ammonia, phosphate etc. with some bacteriological analysis have been assessed and the results are compared with the standards given by WHO except turbidity and total coliforms. The samples were collected from three different sites of the lake i.e. Littoral, Pelagic and Monastery. The data reveals no significant changes in pH and temperature at any sites during both seasons but the turbidity is found to be more in dry season than wet season. However the coliforms numbers were TNTC (too numerous to count) near lake edges. The significant changes are observed in other parameters like nitrate, ammonia and phosphates with respect to seasonal intervals.

Keywords: Water parameters, water pollution, water

1. Introduction
Water having a vital role in all aspects for humans and ecosystem survival and health. People on the globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Thus, its quality is also important. Surprisingly, most of this water is largely unavailable for utilization [1]. Clean water is an essential resource for drinking, irrigation, industry, transportation, fishing, support of biodiversity, and for absolute aesthetic enjoyment. From ancient times, people have chosen to live near water; settling in river valleys, beside lakes, or along coastlines. For as long as humans have lived near waterways, they have also used them to wash away their wastes and pollute water bodies [2]. Due to increased human population, industrialization, use of fertilizers and manmade activity water is highly polluted with different harmful contaminants. Evaluations of water quality parameters are necessary to enhance the performance of an assessment operation and develop better water resources management and plan. Fish survival, diversity and growth; recreational activities such as swimming and boating, municipal, industrial, and private water supplies, agricultural uses such as irrigation and livestock watering, waste disposal, and general aesthetics-all are affected by the physical, chemical, biological, and microbiological conditions that exist in watercourses and in subsurface aquifers. In this study, assessment of water quality of Lake Hyqe was conducted with respect to time and space over a period of one year, which shall cover all seasonal changes in the water quality due to environmental and human interference. The water quality parameters are broadly classified into three categories such as chemical, microbiological and pesticides parameters. The first group parameters which generally include temperature, pH, dissolved oxygen, conductivity, and turbidity are the important one and easily determined by portable water quality analyzer. Whereas the levels of nitrate, ammonia and phosphate by spectrophotometric procedures.
When water becomes polluted, it loses its value economically and aesthetically, and can become a threat to human health, the survival of aquatic organisms and wildlife that depend on it [3]. The quality of potable water and the threat of waterborne diseases are critical public health

issues in many developing countries. The lake edge is the interface between water and land. It is often a region of dynamic physical processes, and high biodiversity and productivity, and it is also serving as a crucial habitat for terrestrial and aquatic plants and many invertebrates, fish and birds during all or part of their life cycles [4]. Nevertheless, majority of these studies concentrate on rivers and streams that are found near the capital. This, therefore, indicates that studies on the Lake Hyqe as it is the primary source of water for a range of activities.

Lake Hyqe is a highly valuable resource area. It is a focal point for tourism, it attracts tourists by its natural beauty, or who come to swim, or explore. It has long been important to lake area inhabitants as a food resource and for their religious and cultural associations and it appreciates peoples to invest their capital at its surrounding area. However, using lake in these ways has altered lakeshores through artificially manipulating lake levels. Lake Hyqe provides a habitat to different fish species, water birds and aquatic organisms. It also plays an economical role via tourism and fishery, and most importantly it provides drinking water to the local inhabitants [4]. Though much research has been conducted in Lake Hyqe, they were concentrated on fish biology, fishery management, limnology and ecology. Currently the lake watershed has been degraded, littoral vegetation has been destructed and the constructed Lodges are releasing their wastes to the lake Therefore assessment of water quality of Lake Hyqe is timely and important study aimed to fill the gap in water quality assessment of the lake that used for more peoples living around the lake.

2. Material & Methods

2.1 Study area

The lake Hyqe adjacent to the Dessie town serving as the major water reservoir and it is utilized for the surrounding human consumption, and aquatic lives. The Lake Hyqe is situated at 30 km from the Dessie town.

Lake Hyqe is located in the north central highlands of Ethiopia. It is a typical example of highland Lake of Ethiopia with volcanic origins. Geographically it lies between 110 3' N to 11^0 18' N latitude and 39 ^{0} 41' E to 39^0 68' E longitude with an average elevation of 1911 meter above sea level. The Lake has a closed drainage system and the total watershed area is about 77 km^2 of which 22.8 km^2 is occupied by Lake Hyqe. According to Molla *et al*. (2007) [6], the average depth of Lake Hyqe is 37 m, and the maximum depth is 81 m. The only stream that entering the lake is the Ancherka River, which flows into its southeast corner, but now permanently dry due to upper irrigation scheme and it is known, there is no drainage out of it. Lake Hyqe is classified as a small highland lake with fresh water. It has never been saline; the predominant cations and anions are magnesium and carbonate/ bicarbonate, respectively.

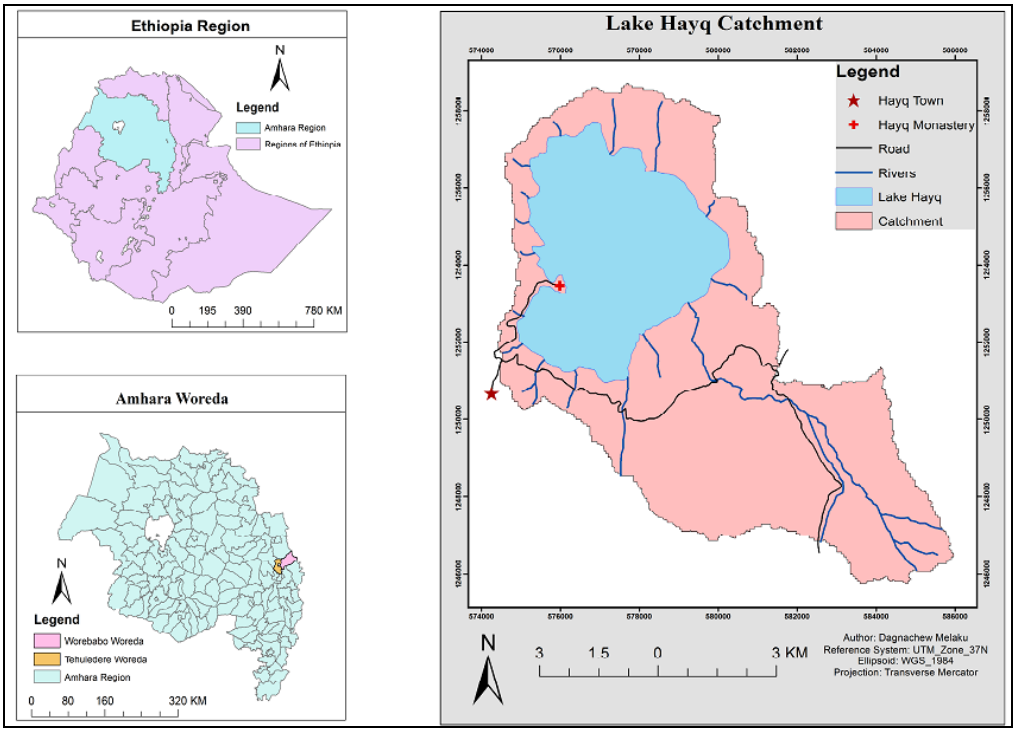

Fig: Map of Lake Hyqe clipped from Amahara Region and Ethiopia.

2.2 Sampling

The water samples were collected for a period of one year at intervals. The data was categorized, depending on seasonal variations into dry season (January to April) and wet season (July to October). The sampling sites are selected based on the relative importance, location and magnitude of human influences. The samples were collected at different sites of lake, Site-1, 2 & 3 (Littoral, Pelagic & Monastery respectively).

2.3 Physio-chemical Parameters

Physio-chemical parameters, Temperature in ^oC, pH and Turbidity were measure by using portable digital multimeter. The total coliforms data was taken from these sites using Potakit in collaboration Hyqe Water resource and management office. Other parameters Nitrate (by Cadmium reduction method), Ammonia (by Salicylate method), Phosphate (by Phosphate version -3 Ascorbic acid method), were estimated by using HACH-Spectrophotometer, DR-

2400. The collected data were statically analyzed by using Prism-5 software.

3. Results & Discussion

Seasonal variations were noted in physicochemical properties, physiochemical parameters of water were analyzed and assessed in order to understand and comprehend the variations of the various parameters at different sites during the seasonal intervals of lake.

3.1 Temperature

Water temperature is one of the most influential environmental factors affecting both the metabolism and growth of living organism and their body composition [5]. In considering the health of organism it is necessary to consider their maximum and optimum value. In the present study the temperature of lake at different sites during dry as well as wet periods were recorded. In the dry period the temperature ranges from 26 ºC to 23 ºC with an average range of 25 ºC. Whereas during wet period temperature ranges from 27 ºC to 22 ºC with an average temperature of 24 ºC. In this study no significant changes in the values of water temperature at various sites during dry and wet periods were observed (Fig-1). This range of water temperature is favourable for all living organisms according to the result obtained [6, 7]. Temperature seems to have pronounced effect on the rate of carbon di-oxide fixation by phytoplankton. In addition temperature effects the bacterial activities which responsible in the decomposition of organic matter for nutrient recycling [8].

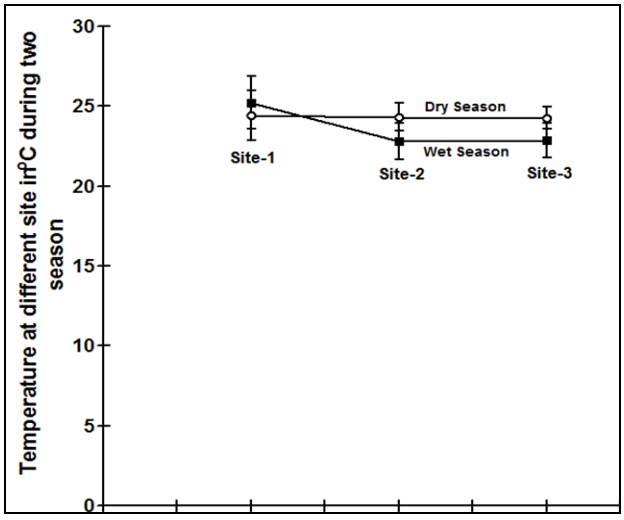

Fig 1: Temperature at different sites in different season in lake.

3.2 Hydrogen ion concentration

Hydrogen ion concentration plays an important role in the biological processes of almost all aquatic organisms. The regional and seasonal variation of pH values in lake water are presented in graphically in figure-2. The pH of investigated lake water fluctuated between 6.8 in dry period and 7.02 during wet period. pH values from 7.0 to 8.7 are suitable for aquatic organism and more productivity [9]. Another study in support of this study indicates that the pH value of water according to target water quality range (TWQR) for domestic use is 6-9 [10, 11]. In general it can be concluded that the pH value in lake water lies within the permissible range for aquatic as well as domestic use.

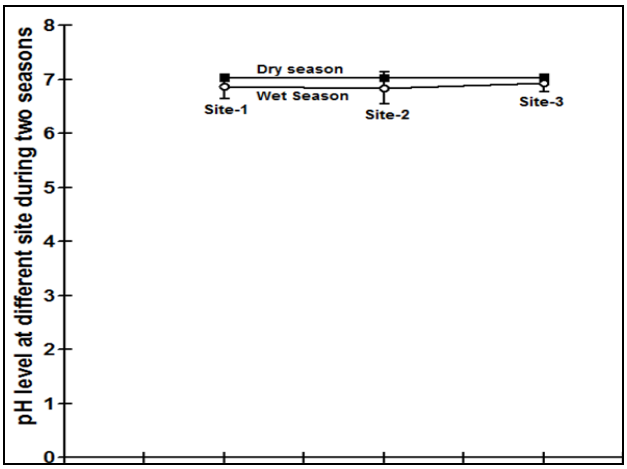

Fig 2: ph level at different site of lake in different season

3.3 Turbidity

It is an important indicator of suspended sediment and erosion level. The study reveals that the turbidity during wet period is highly increased than dry period. Most significant difference is reported at site-1 as compare to site-2 and site-3 (p<0.001). Results are graphically represented in figure-3. The turbidity of lake water is found to be higher than the prescribed limit (>5NTU) for drinking and recreational purposes [12], which is 6.9 NTU during wet season, whereas during dry period the turbidity was reported as 3.95NTU which are in the permissible limit but is near to maximum limits. High turbidity reported during wet period may be mainly related to flood water originating from Ethiopian highland which is known by it's over turbidity [13]. High turbidity at site -1 is also supported by the fact that site-1 i.e., Littoral region which is populated region among all the three sites. Several tourist restaurants or human interference activities are performed at these sites. On the other hands at site-2 and site-3 (pelagic & Monastery), there is not much human interference and other activities, therefore the turbidity is within the permissible limits of drinking and recreational activities. No significant changes are found at other both sites-2 & 3 during the two periods. The consumption of more turbid water may constitute a health risk as excessive turbidity can protect pathogenic microorganism from the effect of disinfectant and stimulates the growth of bacteria [14].

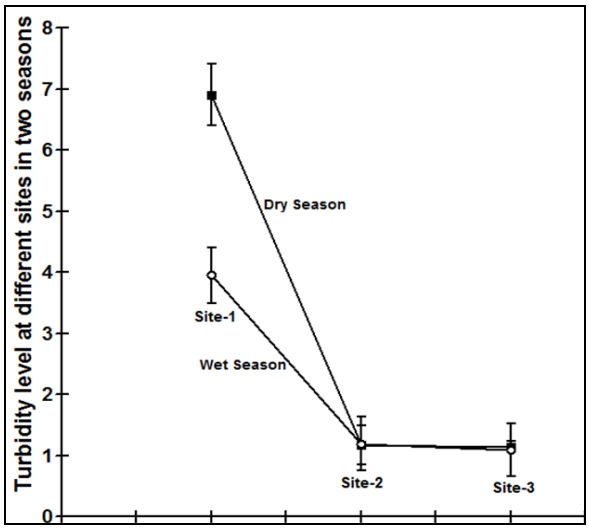

Fig 3: Turbidity level at different site of lake during different season.

3.4 Total Coliforms

Total coliforms are found to be higher at all the sites during wet season than dry. However the coliforms numbers are too numerous to count (TNTC) near edges of lake that indicates the edges are releasing their waste directly in to the lake. The purpose of total coliforms count in water bodies was to estimate the number of coliforms in water sample as an index of magnitude of biological contamination. It is an important parameter for checking possible sewage contamination.

During the study the result shows mean value of T. coliforms during wet period as 30 MPN/100ml whereas during dry period as 25.5 MPN/100ml. which are higher than the recommended limits. Especially significant higher values are observed at site-1 which is near to loges which may be as a result of human interference as restaurants and other activities. The wastes are directly in to the lake water. On the other hand at site-1 &2 the concentration of total coliforms is observed to be higher during both the periods than the recommended limits for drinking water less than 10MPN/100ml [15].

3.5 Nitrate

The concentration of nitrate is used as an indication of level of micronutrients in water bodies and has ability to support plant growth. Our study shows marked elevation in the level of nitrate during wet period than dry. The relative high concentration during wet season is highly significant with mean (0.955, $p<0.0003$) than the dry season with mean (0.403). The higher values of nitrate could be interpretive on the bases of the decomposition of organic matter as well as large amount of drainage wastage, which may be the significant feature of the higher values of nitrate at site-1. Whereas lower values during dry season are mostly due to its assimilation by phytoplankton and aquatic plants during its bloom, this leads to rapid removal of dissolved inorganic nitrogen compounds from the eutrophic zone. Though the concentration of nitrate are within the permissible limit of WHO (2004, 1984) for drinking aspects which is 10mg/litre, excess nitrate in drinking water causes infantile methaemoglobinaemia, which acts on haemoglobin in children, leading to poor oxygen uptake at the cellular level (WHO,1984). According to Murdoch *et al*, 2001, high nitrate content (<1mg/litre) is not conductive for aquatic live, the maximum limit at site -1 to some extent may be dangerous or harmful for aquatic life during wet period. Nonetheless, in unpolluted waters the level of nitrate/ nitrogen is usually less than 0.1mg/litre [16], the relative higher concentration of nitrate recorded may be due to relatively lower content of dissolved oxygen that inhibits the rate of chemical oxidation of ammonia. Our study indicates the overall the lower level of nitrate recorded in this study indicates that sources of pollution from agriculture is not yet significant for the lake aquatic environment specially in the terms of spatial measurement. Our study indicates the concentration of nitrate in Lake Hyqe is within the permissible limits for drinking and irrigation [15].

3.6 Phosphate

Phosphates are usually present in environment in low concentration which limits plant growth. High phosphate levels can come from manmade sources such as septic systems, fertilizers runoff and improperly treated waste water. Phosphate enters the water as a result of surface runoff and bank erosion. In this study high concentration of phosphate were found during wet season than dry. Significant changes were recorded during wet period ($p<0.044$) with mean (0.075) than in dry period (0.057). High values of phosphate may be due to the effects of drainage water enriched with phosphorus compound as a result of the use of detergents and soaps as well as discharges of waste water directly entering in to the lake system. It is above the maximum permissible limit according to WHO (1984) and EPA (2003) that may ranges from 0.005 to 0.02 mg/litre in water for different purposes and healthiness of water ecosystem. Hence the lake is categorized in Eutrophic state index as Carlson (1977). Increased concentration of phosphate and nitrate nitrogen in lakes resulted in enhance productivity [17]. In contrast the mention parameters reveal decrease levels during dry period on the bases of increasing uptake by phytoplankton. According to Rast *et al* (1989) increased in nitrogen and phosphorus one or the other of which tense to limit productivity will lead to Eutrophication. The marked elevation are observed at site-1 which shows the algal blue that can choke out other plants and completely take over the water. This will consume oxygen dissolved in water and as oxygen level will decrease it will negatively effects the quality of aquatic animal life.

3.7 Ammonia

Ammoniacal nitrogen is commonly reduced from decomposition of urea and protein by products, thus it is normally abundance as domestic waste in hydrological ecosystem [18]. The relatively high concentration of ammonia during wet period (2.49) were observed as compare to the dry period (1.42). This may be due to major contribution of ammonium pollution may come from septic systems, although decomposition of ammonium may occurs in the drain field pathways (same). The significant change is found in the levels of ammonia on both the periods ($p<0.004$), which is significant values. The permissible limit according to WHO range is recommended in between 0.2 to 2mg/litre for healthier aquatic life. The high concentration of ammonia observed in this study may be due to the relatively lower content of dissolved oxygen that inhibits the rate of chemical oxidation of ammonia, showed that under anaerobic condition the decomposition of organic matter stops at ammonia level [19]. The highest is observed at site -1 as compare to 2 & 3. The reason behind this may be human activity, play important role as contributor to Ammoniacal nitrogen. Several previous study related to agricultural field impact reported that an application of fertilizers used inorganic nitrate content could be a significant source of high concentration of ammonium nitrate in lake ecosystem. Otherwise the uses in non-agricultural areas often associated with low levels of ammonium contents. The lower levels during dry period are probably due to its utilization by phytoplankton. Since there were no large scales agricultural activities around site-3 of the lake, agricultural activities will not be significant source of ammonia at this section. However our study shows dangerous or harmful effect for the aquatic life during the wet period on the other hand its concentration lies within the permissible limits for the drinking or irrigation according to recommended range of WHO that is 12mg/litre.

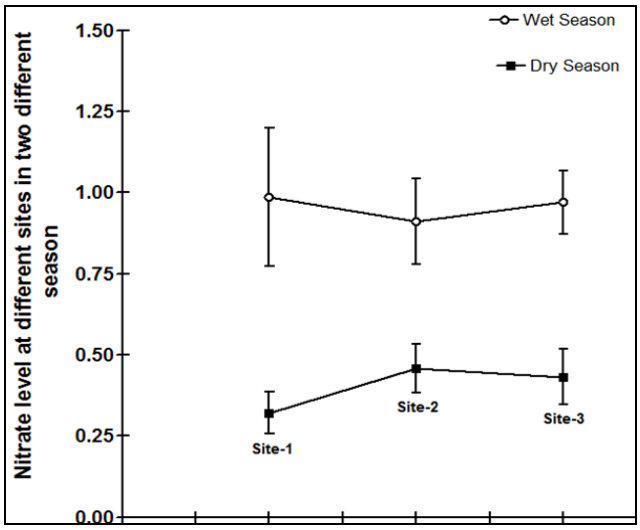

Fig 4: Nitrate level at different site of lake during different season.

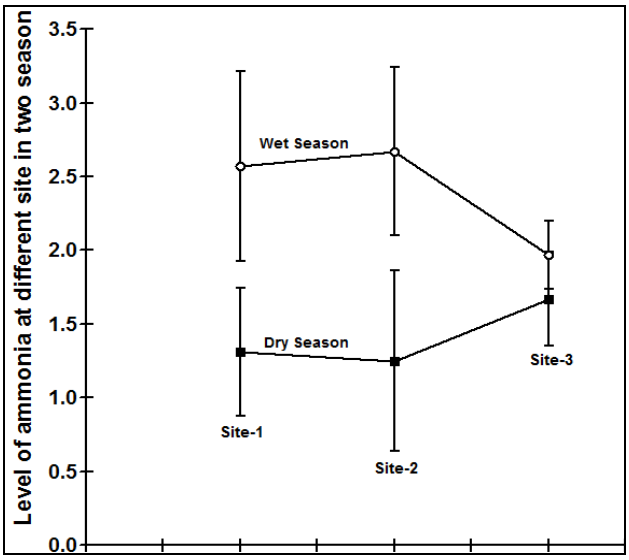

Fig 5: Level of Ammonia at different site of lake in different season.

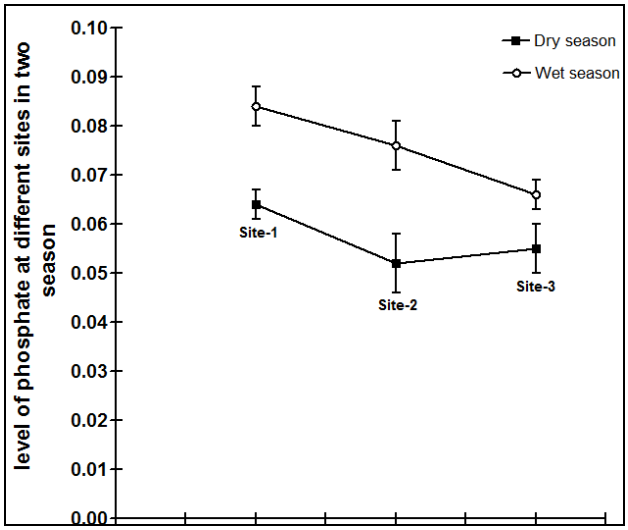

Fig 6: Level of Phosphate at different sites of lake during different season.

4. Conclusion

The current study evaluates the physiochemical and bacteriological water quality characteristic of Lake Hyqe for multiple designated water used like drinking, irrigation, recreation and aquatic life. The parameters of water quality analyzed and examine from various sampling sites during seasonal variation as dry and wet periods shows unsuitability of water for drinking in some aspects for example ammonia and phosphate concentrations but with some great care it can be used for recreational activities as well as for irrigation and aquatic life. The study indicates quite significant seasonal influence of rain falls on the lake aquatic ecosystem. The study also shows that the present ecotourism activities have minimal impact on water quality except for variations in the Eutrophication parameters namely ammonia and phosphate and bacteriological parameters T. Coliforms (mainly from sewage, from restaurants and boating activities).

Considering future development of the lake as popular ecotourism destination, the water quality of lake should be maintained or improved further. An effective management of waste sewage treatment, possible soil erosion from open-up of land and logging activities in the vicinity of the lake and organic pollutants should be planned and enforced from further detritions.

In conclusion, the lake is also productive and will support diverse number of organism from phyto and zooplanktons, benthos too fishes and macrophytes going by the abundance of chemicals needed for inter conversion of energy. The physiochemical data obtained in this lake could be used as baseline and reference point when assessing further changes causes by natural or anthropogenic in this lake.

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