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# Diatom Diversity of Three Freshwater Lakes in Kolhapur City, Maharashtra

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## Abstract:

**Diatoms are particularly interesting as a potential indicator of water quality. Diatoms are used as bio-indicators of pollution. The study focused on present status of diatom diversity and to determine pollution level of three lakes in Kolhapur city. The study was conducted from September 2012 to February 2013. About 18 species of diatoms were identified from three lakes. Shannon-Wiener diversity index (H'), Evenness index (J'), Species Richness (SR), Index of dominance were calculated for diatom. All the three lakes showed species richness in between 1.73 - 2.27. The highest Species Richness was found in Rankala lake where as less for Rajaram lake. Also, Species Richness for all the three lakes was in between 2 to 2.5. Species Eveness Index was observed to be slightly high for Kalamba lake while it was least for Rajaram lake. The study revealed that the diversity of diatoms varies seasonally which is higher in winter season and lower during the month of September and October (post monsoon season) indicating more pollution in the lakes. The major species *Aulacoseira ambigau, Navicula cryptocrphala, Synedra ulna and Cymbella turgidula.***

**Keywords:** Diatoms, Environmental indicators, Diversity, Lakes, Kolhapur.

## 1.0 Introduction:

Phytoplanktons constitute the basis of nutrient cycle of an ecosystem and hence play an important role in maintaining equilibrium between living organisms (Wetzel, 2001). Diatoms are abundant phytoplankton in aquatic habitats which are very good indicators of changing status of water bodies and abiotic factors. They are the primary producers of aquatic ecosystem, respond quickly to environmental perturbations. They are playing important role in carbon fixation in many lakes and the oceans (Smetacek, 1999; Reynolds, 2006) . They can exist in colonies on wet submerged surface or as solitary cell in open water (Round *et al.* 1990). These are unique among algae because of their cellular characteristics such as siliceous wall and chrysolaminarin. Diatoms in the form of individual cells are most commonly present in the range of 10 – 200 mm in size. As these are relatively large cells with dense cell walls, it can cause them to sink readily (Smol *et al.* 1984). Diatoms have very short lifespan and they can also response quickly to environmental changes. The phytoplankton abundance is a result of spatial and temporal changes in physical i.e. temperature, light and nutritive levels and biological variables i.e. grazing pressure and competition, but of the externally imposed or self generated spatial segregation i.e. life cycles (Roy, 2007). The diatoms can form massive blooms in ocean areas with strong physical mixing (Chisholm 1992; Bopp *et al*. 2005), whereas their abundances are typically low in the oligotrophic stable (Boyd and Doney 2002). Their species composition indicate the quality of water in which they are found (Mercado, 2003). Some of the genera of diatoms are pollution tolerant. Palmer,(1980) stated that *Synedra acus*, *Gomphonema sp*., *Cyclotella sp.* and *Melosira sp.* are found in organically rich water and play an important role in water quality assessment and trophic structure. Number of investigators has discussed the role of physico-chemical parameters such as pH, nitrates, phosphates, silica and calcium in the

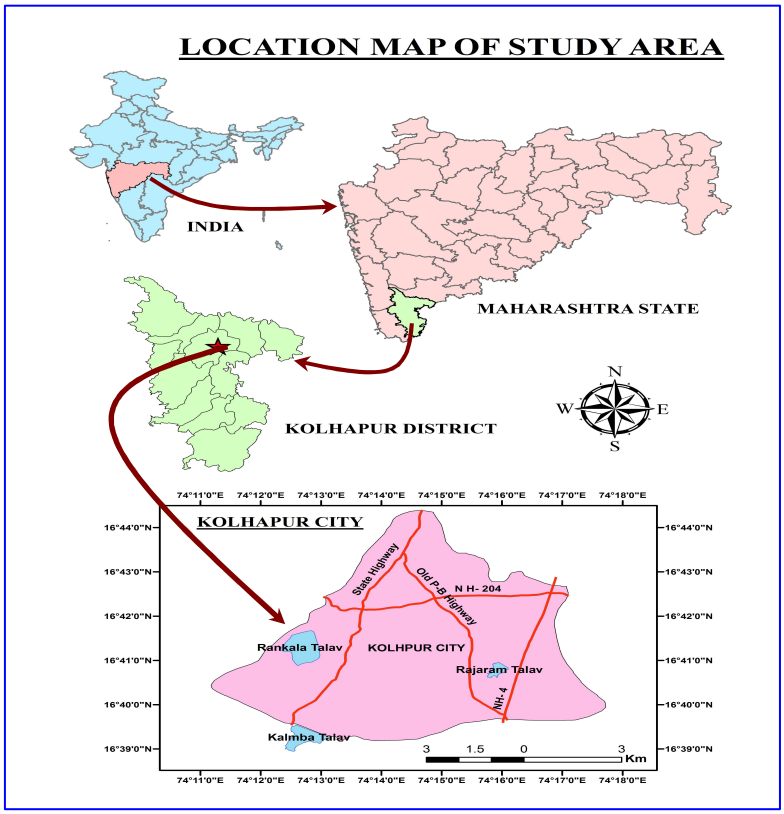
distribution of diatoms (Sabater *et al*., 2007; Alakananda *et al*., 2011). Diatoms have shown to be reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification and metal pollution as well as for general water quality (Bellinger *et al*., 2006; Pan *et al*., 1996 and Gaiser *et al*., 2004). Among several groups, diatom-based pollution monitoring has proved to be rapid, efficient and cost-effective technique has been implemented worldwide to monitor rivers, streams and lakes (Juttner *et al*., 1999; Karthick *et al*., 2011).

Though, a few studies are available on diatoms in river ecosystems, very little research is available on diatom ecology and their role in environmental monitoring programme in Indian lakes. However, no attempts have yet been made to use diatoms to analyse the diversity and richness of diatoms in lakes of Kolhapur city, Maharashtra. Kolhapur city (Latitude 16° 36' N, Longitude 74°21' E), Maharashtra, is situated in the Western part of India. It was known as 'City of Lakes' in the past due to the presence of 24 lakes in and around. However, in the recent past, the lake ecosystems in the city have changed drastically and come into worsen trend because of disturbances in the catchment areas (Jadhav *et al*, 2013). Main objective of the present study was to analyse the diversity of diatoms composition and impact of environmental variables and describe the distribution and periodicity of diatoms in four lakes and to test the ability of LBI (Lange-Bertalot Index) to comparatively assess the quality of lakes.

## 2.0 Materials and Methods:

### 2.1 Study Area

For studying the diversity of diatoms three lakes of Kolhapur city were selected as Rankala, Kalamba and Rajaram lake respectively. Rankala lake is located in the heart of the city and is one of the well known tourist spot of Kolhapur city. Kalamba lake is one of the source of drinking water supply to the city.



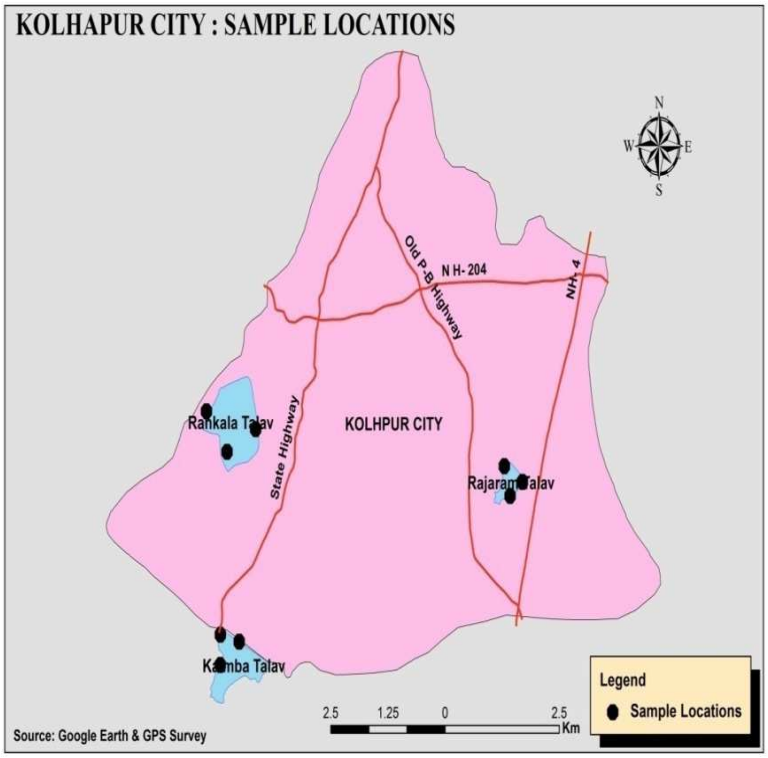



**Table No. 1: Geo coordinates, year and dimensions in Kolhapur city**.

**Diatom collection and analysis:**

| Sr. No. | Name of the Lake | Coordinates | Year of construction | Area | Mean sea level (M) | Depth (M) |
|---|---|---|---|---|---|---|
| 1. | Rankala | $16^0$ 41' 17.21" N $74^0$ 12' 39.60" E | 1887 | 107 hec. | 552.90 | 30 |
| 2. | Kalamba | $16^0$ 39' 18.18" N $74^0$ 12' 39.42" E | 1881 | 63.13 hec. | 597.71 | 14 |
| 3. | Rajaram | $16^0$ 40' 48.58" N $74^0$ 15' 54.77" E | 1928 | 21.6 sq. m | 575.46 | 11 |

Diatoms were collected from all the three lakes monthly during the year 2012 - 2013. Monthly sampling was carried out from September to February from selected sites of Rankala, Kalamba and Rajaram Lake. Collections were made with the help of tray and brush. Stones were cleaned with the help of brush and samples were collected in the tray and this sample is transferred into the plastic bottles. This procedure carried out three times for each lake. Collected samples were stored in the laboratory and preserved with Lugol's iodine for quantitative and qualitative analysis of diatoms. Identification of diatoms up to the species level was made following the key characters suggested by Welsh (1964); Round *et al*., (1990); Gandhi, (1998); Taylor *et al*., 2005 and Karthick *et al*., 2011. Laboratory processing of the diatoms was carried out by following standard methods suggested by Kawecka (2012). Samples were cleaned by using hot HCl and $KMnO_4$ method and slides were prepared. Qualitative analysis of diatoms was done by studying 15 slides for each lake under the microscope. Counting of diatoms was done using Sedgwick Rafter counting chamber. The status of diversity is determined with Shannon-Wiener diversity index (H'), Evenness index (J'), Species Richness (SR), Index of Dominance.

## 3.0 Results and Discussion:

Algae are one of the most rapid bio indicators of water quality changes due to their short life span, quick response to pollutants and easy to determine their numbers. Diatoms remain as benthic or epiphytic forms and can serve as good indicators of organic pollution (Plafkin *et al*., 1989). Hosmani and Mruthunjaya, 2013 also suggested that the diatoms are more precise indicators as compared to other algae that may be of allochthonous origin. The water quality status of any water body can be related with community structure which is based on few assumptions: 1) the natural community evolves towards greater species complexity 2) this eventually stabilizes and increases the functional complexity of the system 3) complex communities are more stable than simple communities, and 4) pollution stress simplifies a complex community by eliminating the more sensitive species (Cairns, 1974*).* Also, it is proven that not only physical environment i.e. temperature, sunlight, etc. decide the distribution of algal population but the nutrients along with chemical compounds like CO2 determines the composition and abundance of phytoplanktons and zooplanktons (Bormans,1998). However, diatom community distribution in a lake is also determined by the combination of physical, chemical and biological factors which is reflected as their seasonal variations.

Total 18 species of diatoms were recorded from Rankala, Kalamba and Rajaram lake between a period of 2012-13. The similar variations in diatoms were observed in the three lakes. The observations revealed that the diversity of diatoms declined gradually and showed its lowest value in the monsoon season while the diversity becomes high during winter season. Philipose, (1960) also reported the same results related to increasing number of diatoms in winter season. Lowest number of diatoms in monsoon season is attributed due to rainfall which dilutes the water and distribute the structure and composition of aquatic ecosystem (Pareek , 2011). *Synedra ulna* and *Aulacoseira ambigue* is a eutrophic species mostly observed in eutrophic lakes. *Cymbella*, *Gomphonema* and *Cocconicus* found in organically polluted water bodies which were observed in all lakes. *Cymbella turgidula* found in oligotrophic to mesotrophic alkaline water with moderate electrolyte contact while *Gomphonema pseudoaugur* species found in oligotrophic to mesotrophic water but not tolerate to critical level of pollution. *Nitzschia* species of diatom is large diverse and ecologically versatile genus occurs in oligotrophic water. *Surirella spp* are found in Rajaram Lake is a large and common freshwater to marine water genus. Another study related to diversity indices showed its potential application in aquatic ecosystem related to quality of water. Rosenberg (1976) and Patrick (1973) have reported that polluted ecosystem shows reduction in diversity. It is reported that species diversity implies both richness and evenness in number of species and equitability for the distribution of individuals among the species (Veducci *et al.*, 2007; Rajagopal *et al*., 2010).

**Table No. 2. Diatoms Recorded from Three Lakes of Kolhapur City**

| Sr.No. | Name of the Species | Sr.No. | Name of the Species |
|---|---|---|---|
| **1.** | *Gomphonema pseudoaugur* | **10.** | *Encyonema silesiacum* |
| **2.** | *Aulacoseria ambigau* | **11.** | *Nitzschia solgesis* |
| **3.** | *Cymbella turgida* | **12.** | *Frustulia vulgaris* |
| **4.** | *Navicula cryptocephala* | **13.** | *Cymbella letoceros* |
| **5.** | *Synedra ulna* | **14.** | *Surirella tenera* |
| **6.** | *Cocconeis pediculus* | **15.** | *Gyrosigma* |
| **7.** | *Protoderma spp* | **16** | *Ulnaria asus* |
| **8.** | *Amphora pediculus* | **17.** | *Amphora submontana* |
| **9.** | *Eolimunai minina* | **18.** | *Navicula species* |

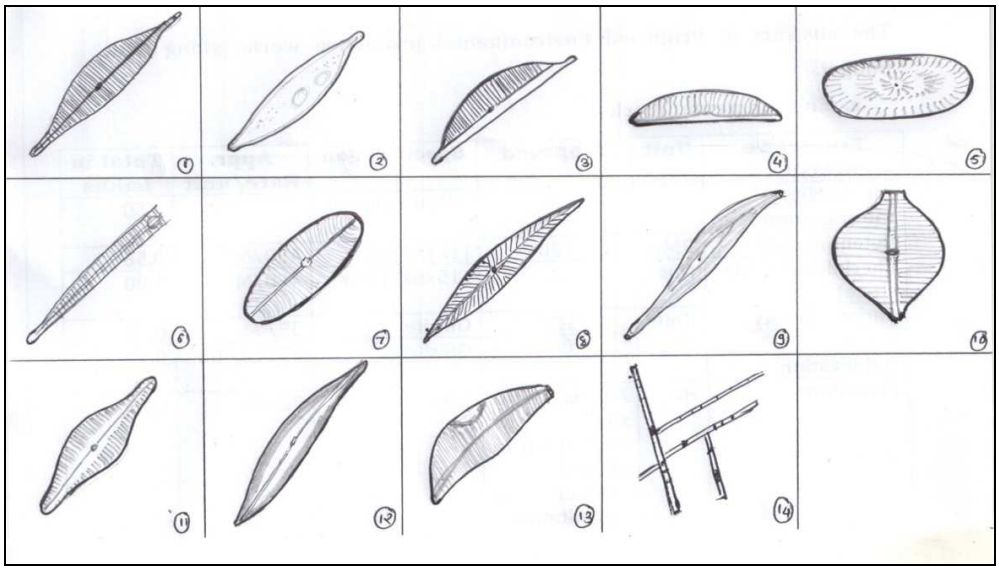


**Figure No. 1: Diatom species observed in three lakes under study.**

*1) Aulacoseira ambigau, 2) Cymbella turgidula, 3) Gomphonema pseudoaugur ,*
*4) Amphora pediculus, 5) Protoderma, 6) Synedra ulna,*
*7) Coconeis pediculus, 8) Surirella tene, 9) Gyrosigma ,*
*10) Amphora submontana, 11) Cymbella leptoceros, 12) Navicula spp.,*
*13) Encyonema, 14) Nitzschia spp.,*

**Table 3: Average Biodiversity Indices of Three Lakes in Kolhapur City**

| Sr. No | Indices | Kalamba | Rankala | Rajaram |
|---|---|---|---|---|
| 1. | Shannon-Wiener Diversity Index | 0.58 | 0.62 | 0.61 |
| 2. | Species Richness | 1.85 | 2.27 | 1.73 |
| 3. | Evenness Index | 0.89 | 0.87 | 0.88 |
| 4. | Index of Dominance | 0.29 | 0.28 | 0.28 |

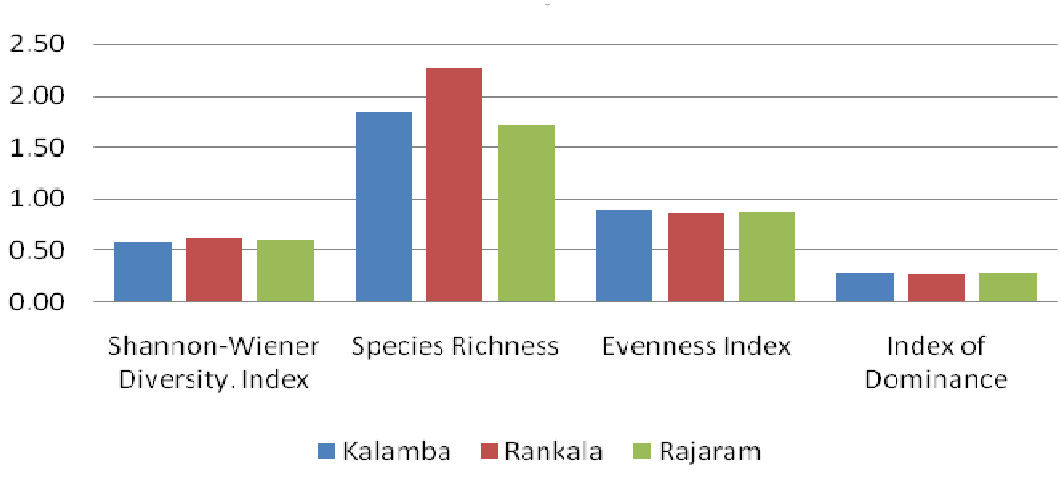



**Figure 2: Diversity indices of diatoms for three lakes in Kolhapur**

**Table No. 1: Monthly variation of diatoms species in Rankala Lake, Kalamba Lake and Rajaram Lake during September 2012 to February 2013.**
*All the values indicate number of diatoms for respective diatom species.

| Sr. No | Diatoms Species | Rankala Lake | | | | | | Kalamba Lake | | | | | | Rajaram Lake | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. |
| 1 | *Gomphonema pseudoaugur* | 66 | 29 | 44 | 20 | – | – | – | 374 | 241 | 331 | – | – | 42 | – | – | – | – | – |
| 2 | *Aulacoseira ambigau* | 454 | 231 | 274 | 334 | 497 | 234 | 313 | _ | 317 | 287 | 35 | 249 | 260 | 211 | 357 | 254 | 372 | 287 |
| 3 | *Cymbella turgidula* | 140 | 181 | _ | _ | _ | _ | 96 | 161 | 23 | 32 | _ | _ | 43 | 163 | 270 | 290 | _ | _ |
| 4 | *Navicula cryptocrphala* | 363 | – | 286 | 414 | 231 | 333 | 224 | 229 | 402 | 368 | 415 | 256 | 210 | 513 | 237 | 309 | – | – |
| 5 | *Synedra ulna* | 187 | _ | 314 | 401 | 237 | 246 | 184 | 311 | 405 | 266 | 311 | 280 | 242 | 240 | 348 | 251 | 36 | 251 |
| 6 | *Coconeis pediculus* | 1 | _ | _ | _ | 271 | 252 | _ | _ | _ | _ | 423 | 215 | _ | _ | 24 | 37 | 356 | 273 |
| 7 | *Navicula* | _ | 206 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 8 | *Surirella tenera* | _ | _ | 240 | 63 | | | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 9 | *Gyrosigma* | _ | _ | 109 | 72 | 287 | 254 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 10 | *Ulnaria asus* | _ | _ | _ | _ | 120 | 214 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 11 | *Amphora submontana* | _ | _ | _ | _ | _ | 162 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 12 | *Protoderma* | _ | _ | _ | _ | _ | _ | 5 | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| 13 | *Eolimunai minina* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 112 | 120 | _ | _ | _ | _ | _ | _ |
| 14 | *Encyonema silesiaus* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 171 | 133 | _ | _ |
| 15 | *Nitzschia solgesis* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 367 | 252 |
| 16 | *Frustulia vulgaris* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 191 | 394 |
| 17 | *Cymbella leptoceros* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 63 | 302 |
| 18 | *Amphora pediculus* | _ | _ | _ | _ | _ | _ | _ | _ | _ | _ | 108 | 257 | _ | _ | _ | _ | _ | _ |

Shannon-Wiener index can be used to determine pollution status of water bodies. According to Wilham and Dorris (1968), the value of Shannon-Wiener index with reference to algae if it is > 3 indicates clean water, the value in between 1 to 3 shows moderate water pollution and < 1 indicates the heavy water pollution. Over all observations shows that, for all the three lakes Shannon-Wiener diversity index ranges in between 0.5 to 1.8. Since the Shannon-Wiener index for all the three lakes is < 1, it shows heavy water pollution in the selected lakes. During the present study this index value for all these lakes was < 1 which clearly indicates heavy water pollution of lakes.

All the three lakes showed species richness in between 1.73 - 2.27. The highest Species Richness was found in Rankala lake whereas less for Rajaram lake. Also, Species Richness for all the three lakes was in between 2 to 2.5 and it was higher in the month of February while low in month of September**.** Singh and Swarup (1979) stated that higher temperature promotes growth of diatoms. Patil *et al* (2013) studied seasonal variation of diatoms in Lotus lake in Toranmal Nandurbar district of Jalgaon district of Maharashtra State , India and found similar results. Species Eveness Index was observed to be slightly high for Kalamba lake while it was least for Rajaram lake. Evenness index was high in the month of February i.e. in the winter and low in the month of September i.e. in the rainy season. Among 18 species, *Gomphonema pseudoaugur, Aulacoseria ambigau, Cymbella turgida, Navicula cryptocephala, Synedra ulna* and *Cocconeis pediculus* were reported from all the three lakes.Some species like *Protoderma spp, Amphora pediculus* and *Eolimunai minina* showed their dominance in Kalamba lake while few species like *Encyonema silesiacum, Nitzschia solgensis, Frustulia vulgaris* and *Cymbella letoceros* were only present in Rajaram lake. Some species like *Surirella tenera, Gyrosigma, Ulnaria asus, Amphora submontana* and *Navicula species* were observed only in Rankala lake. Dominance index value seems to be equal for all the three lakes.

## 4.0 Conclusion:

Considering the diversity indices, it is clear that all the three water bodies show heavy water pollution. It is needed to take precautions to avoid mixing of organic pollutants in all the three lakes especially in Kalamba lake which is the source of potable water supply to the Kolhapur city.

## 5.0 Acknowledgement:

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