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HYDROBIOLOGY OF RAW WATER RESERVOIR AT ADRA, PURULIA DISTRICT, WEST BENGAL

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INTRODUCTION

Adra lake (also known locally as 'Saheb Bandh'), is a relatively small raw water reservoir [Catchment area–4.18 sq. kms, full reservoir level (FRL)–550.50 ft. and maximum water spread area *ca.* 2.5 sq. kms], located about 5 km. north of Adra, a Indian Railways township, in Purulia district (latitude 23°42´ N and longitude 87°01´ E), West Bengal. The oligotrophic raw water lake serves as a source of drinking water for Indian Railways Divisional Headquarters township, located down stream. Limnology of raw water reservoir has not attracted as much attention in India (Srinivasan *et. al.*, 1965). Saheb bandh is a well conserved, protected, managed drinking water reservoir and therefore, offered an interesting academic scope for initiating hydrobiological studies.

The oligotrophic raw water body was investigated, in detail, for evaluation of water quality and associated wetland faunal diversity. A complete physico-chemical profile and biotic attributes-wetland faunae, *etc.*, of the raw water reservoir is the first attempt on limnology of the lake from the region. Despite the vigorous south-west monsoons in the region, and depression induced cyclonic rains specially during the period of study, the lake waters were clear and transparent, devoid of turbidity, *etc.* The relatively well conserved catchment (under the control/management of the Railways as also Territorial Army limits around) ensures protection from abuse/misuse of the watershed/catchment area of the surface water reservoir. Mild growth of limited submerged aquatic vegetation–*Hydrilla* spp. *Marsilea* spp, and *Nympha* spp. *etc.*, around the littoral regions in no way adversely influences the transparency of the lake waters. The relatively undisturbed aquatic habitat is also home to small number and variety of water fowls.

MATERIAL AND METHODS

The concerned Railway Authorities (Divisional Manager, Adra Railways Division, S.E. Railway was approached for permission and facilities. The *ca* 2.5 sq. kms. water body has a masonry wall bandh with a 'kutcha' motorable road (inspection road) that separates the reservoir upstream from the filter beds and pump house down below. An irregular shaped water spread area of the reservoir is otherwise surrounded by fields and small scrub forests on western, northern and north-western edges. Field studies were initiated in late south-west monsoons (Sept./Oct., 1995) continued through the following winters (Feb., 1996) and summer seasons (April, 1996). Survey and sampling for biological collections–zooplankton, wetland fauna, and water samples were carried out between 8.00-12.00 hours. [The small raw water storage tank, located in flat plains, was divided into four limnologically significant sites S_1, S_2, S_3 and S_4 to ensure random sampling] (Fig. 2). Collections of other littoral fauna and nekton, for an overall evaluation of wetland fauna *vis-à-vis* the lake water quality was also attempted. Upper pump house, a significant land mark with a circular deep bore well was choosen as sampling site1 (S_1), the Wier level and or the spill way as S_2 while Ghodekanta (south-eastern) and Dawan mahal village (north-eastern) were choosen as S_3 and S_4 respectively. The irregular shaped water spread area has minor aquatic rooted vegetation (*Phragmites*-reeds) and free floating macrophytes like

Fig. 1 : Outline map of 'Saheb Band', raw water reservoir at Andra Railways township, Purulia district, West Bengal showing various sampling sites (S1-S5), and other features of littoral habitats of the small lake. Inset box. Groupwise % composition of zooplankton community.

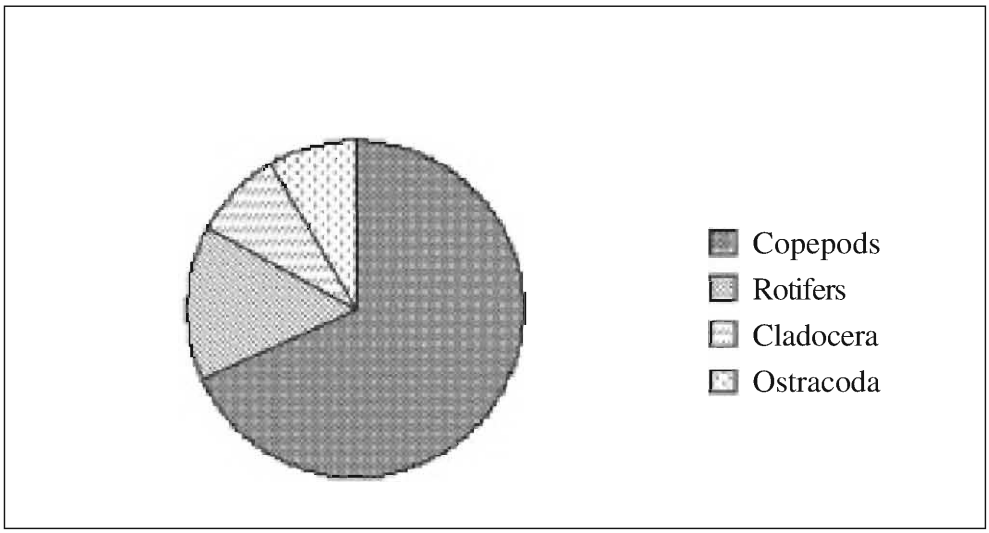

Fig. 2 : Pie diagram showing composition of zooplankton community in Adra lake, Purulia District, West Bengal.

Table 1 : Showing range of values of different physico-chemical parameters in littoral and mid waters in raw water reservoir, Adra, West Bengal.

Parameters	South-West Monsoons, 1995				Winters, 1996				Summers, 1996			
	Upper Pump House	Ghora-kanta village	Wier level	Seasonal range values	Upper range values	Ghora-kanta village	Wier level	Seasonal range values	Upper Pump House	Ghora-kanta village	Wier level	Seasonal range values
pH	6.9	7.05	7.1	6.9-7.1	6.8	7.01	7.1	6.8-7.1	6.9	6.85	7.4	6.85-7.4
Electrical Cond.,micro mhos/cm	40	10	30	10-40	30	25	35	25-35	-	130	410	130-410
Turbidity, NTU	5	5	10	5-10	5	10	5	5-10	-	20	25	20-25
Total Dissolved Solids mg/L.	62	62	107	62-107	63	109	60	60-109	-	85	267	85-267
Phosphates , P-PO_4 mg/L.				.095-.223	NE	NE	NE	-	NE	NE	NE	-
Nitrates,N-NO_2 mg/L.	1	1	1	1	1	1	1	1	-	5	8	5-8
Ammonia Nitrogen N-NH_3 mg/L.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	-	Absent	Absent	Absent
Total Nitrogen, N mg/L.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	-	Absent	Absent	Absent
Sulphates, SO_4, mg/L.	5	5	10	5-10	5	10	5	5-10		15	40	15-40
Silica, SiO_2, mg/L.	7	8	15	7-15	7	15	8	7-15	-	15	20	15-20

Lotus and *Nischea* sp. while *Hydrilla* vegetation abounds in areas around spill way, the retaining wall providing support to floating *Hydrilla* vegetation. The field/laboratory methodology followed for analytical instrumental procedures, were standard limnological manuals (Lind, 1979, Wetzel & Likens, 1979, *etc.*) Inorganic plant nutrients like the different forms of Phosphorous (P) and Nitrogen (N) were got analysed from outside laboratory of repute following no facility. The results of physico-chemical analyses and nutrients have been tabulated in tables 1 and 2 respectively.

The physical factors like pH, electrical conductivity and total dissolved solids were estimated *in situ* with the help of electronic dip testers (Hanna make pH, dip C, dip D, *etc*). Water samples for the analyses of turbidity and inorganic plant nutrients, were collected in wide mouth PVC containers (Torsons bottles with plugs and screw cap) and pretreated (filtered, acidified to pH < 2). The various forms of phosphorus and nitrogen were analysed using standard chemical procedures in vogue (Lind, 1979 and Standard Methods–APHA, AWWA and WPCF, 1985). Plankton samples were collected by towing the plankton net (No. 25) from the subsurface regions in all sampling sites. Field studies were initiated during the year 1995-1996 (November, 1995 and February through April, 1996) to cover the different seasons–south-west monsoons, winter and summer. Allied wetland faunal collections were made by hand picking and operating cast nets and identified by referring standard taxonomic works on the respective faunal groups. The prefixed, sorted zooplankton samples were identified using the standard Indian/Regional Works (Patil and Gouder, 1989, Battish, 1992, Sharma 1998 and others) while fishes were identified using Talwar and Jhingran, 1991 and Jayaram, 1999.

WATER QUALITY AND ZOOPLANKTON

Table-1 incorporates the various range of values of different basic physico-chemical parameters analysed in littoral waters and mid lake (Wier level) while Table-2 documents range of values of various forms of inorganic plant nutrients–phosphorus and nitrogen, estimated, in the raw water reservoir. The lake waters are mildly alkaline, relatively nutrient poor (oligotrophic) with a sprinking of wetland fauna–zooplankton, crustacean decapods, malacofauna and small diversity in bird/fish nekton, characteristic of clean waters (Table-3).

Colour : Neither true nor apparent colour, was empirically estimated, save for subjective visual observations, and may be best described as clear and colourless, equivalent to zero platinum units on the platinum colour scale. Unlike the natural, senescent eutrophic lakes, the raw waters were devoid of seston (plankton) and tripton (non-living matter). Aesthetically speaking, the raw water in the reservoir were clean and colourless, and fit for end use, well within the prescribed limits of colour for subsurface waters for drinking water purpose.

Depth : The depth (Z), a physical morphometric factor of relevance in limnological studies, was measured, at random, often during mornings *ca* 8-12.00 hours, using a nylon rope, calibrated at intervals and having a lead weight tied to its end. The depth measurements, wherever feasible at S_1 (Locomotive well), Wier Level 1 and 2, *etc.* ranged between 3.1 to 3.3 m during the south-west monsoons and were estimated only during the initial field visits.

Secchi Disc Transparency (Zsd, m). *In situ* field measurements, using 20 cms diameter black and white Secchi disc, with calibrated line (Nylon rope), revealed high transparency, even during the south west monsoons (Zsd, m 1.6-1.7 m), indicative of high clarity and transmittance of incident solar light with depth. Secchi disc transparency values correspond closely to percentage transmission (Wetzel, 1983) and help compute, by extension, extinction coefficient –D = 1.7/ Zsd,m. The extinction coefficient values in the raw water reservoir worked out to 0.9770 to 1.0623, fairly high, indicating presence of euphotic zone in upper column of raw waters.

Temperature (°C). The ambient atmospheric and subsurface water temperatures was measured, *in situ,* using a simple Hg laboratory thermometer. The annual range of values of atmospheric and subsurface waters varied widely from 23 to 29°C and 26 to 29°C respectively.

pH. *In situ* pH estimations of raw water were made in field, from different sampling sites, including in flows

and out flows (Wier Level) as also littoral regions, *etc.* and varied from 7-7.9 in the lake. The pH value revealed no seasonality or seasonal pattern with south-west monsoons recording values between 7.0-7.9, winter season 7.0-7.6 and summers between 7.0-7.9. The well conserved immediate water shed around Adra reservoir has no point/non-point source of pollution due to anthropogenic activities, therefore the pH values fall well within the permissible range (pH 6.0-9.0) for inland surface waters for its potability purpose (BIS-10500, 1991). In fact, the pH values in the reservoir, in tandom other physical factors, Zsd, m *etc.*, are conducive to wide array of biotic life-neuston and nekton, besides plankton, in the raw water reservoir (Table-2).

Electrical Conductivity (μ mhos/cm). Electrical conductance, simply stated as a measure of the dissolved mineral content (salinity), is directly proportional to ions in water and *vice-versa* and an important physico-chemical factor influencing biotic life forms. *In situ* electrical conductivity estimations were made using electronic dip (conductivity) tester which showed variations between 10-410 μ mhos/cm, following well within the permissible limits for natural water (20-1,500 μ mhos/cm., Boyd, 1990), as also the Indian Standards for inland surface waters for use as raw water for potable purposes. No seasonal pattern was detected, save that the values during the south-west monsoons were marginally higher, perhaps following more surface runoffs during rainy seasons.

Total Dissolved Solids. Apart from their significance as a physico-chemical factor in raw/drinking water supplies, total solids, loosely speaking, also affect transparency, indeed, turbidity too, in inland lakes and therefore or a significant factor in affecting minor forms of aquatic life, including fish, plankton, *etc.* Total solids estimations, again *in situ,* were made using electronic dip tester/meter (Hanna make-dip d) and ranged between 10 or 100 mg/L. falling well between permissible range for specified standards for raw surface water (500-1500 mg/L) for drinking purposes (BIS-10500, 1991). The extremely low total dissolved solids content in the raw water reservoir is indicative of good aesthetic water quality and insignificant run offs from the surrounding environment *viz.*, forests, agricultural fields around, *etc.*

Turbidity (Nephlometer Turbidity Units, NTU). Besides *in situ* estimations of transparency (Zsd, m) using Secchi disc, turbidity was estimated through Nephlometer and ranged widely from 05-25 NTU's, on a yearly average, showing no clear cut seasonal constancy, save for marginally higher values during south-west monsoons, especially following heavy cyclonic rains around late October, 1996, prior to sampling, and attendant runoffs. From view point of aesthetic water quality, the raw water are not the least turbid, indeed are clear and transparent and fall within limits (5-25 NTU) prescribed for inland surface waters, when used as raw water for public water supplies (BIS-10500, 1991).

Nutrients : No previous studies exist on the role of various forms of inorganic nutrient in raw water reservoir *vis-à-vis* their dynamics and biotic utilization in lacustrine system especially in oligotrophic waters, save one from a relative large mesotrophic lacustrine system (Kanwar jheel, Begusarai District, North Bihar, Siddiqi and Ramakrisha, 2002).

Phosphorus : Compared to the different forms of nitrogen available in aquatic ecosystems, inorganic phosphorus (as orthophosphate–PO_4) is the most significant form, while all the others (> 90%) is the organic phosphorus. These, together with other forms, generally limit and influence biological productivity in aquatic ecosystem. Total phosphorus content consists of 'particulate' and 'dissolved' fractions, which in turn consists of (i) orthophosphate (PO_4), (ii) polyphosphates, (iii) organic colloids and (iv) phosphate esters (Wetzel, 1983). The sum of all forms of phosphorus content, P tot, is good measure of the fertility of an natural aquatic ecosystem.

The Soluble Reactive Phosphorus (SRP) or the Orthophosphate (P-PO_4), ranged between. 0.223-0.95 mg/L while the total organic phosphate–0.195-0.345 mg/L, total organic phosphate or polyphosphates-0.226-0.698 mg/L and condensed phosphates 0.692-1.48 mg/L are relatively lower than all the other phosphorus fractions analysed. The total phosphorus (0.226-0.698 mg/L) as also the orthophosphate concentrations in Adra raw water reservoir are pretty low, well in agreement with known concentrations for low unproductive, uncontaminated waters (< 1 mg/L). In line with the established known pattern (P-PO_4 10-50

mg/L), inorganic soluble phosphorus values are low (0.095-0.223 mg/L) and often measures only to fractions of total phosphorus (0.00066%-0.00155%) as it is cycled rapidly in the zone of utilization (trophogenic zone), (Wetzel, 1983). Further, the ratio of soluble reactive phosphates or P-PO_4 to other chemical forms is approximately 1 : 20 or 5%. Based upon external loading/distribution of various chemical fractions of phosphorus in Adra reservoir, the lake may be categorized as *oligotrophic* (nutrient poor) or unproductive. Further, inferring from known concentrations of various forms of nitrate-nitrogen and phosphorus in the littoral trophogenic zones in Adra lake, the relatively higher total nitrogen content (4.48 N mg/L), it may be assumed that as with most oligotrophic lakes, biological productivity in Adra reservoir too appears to be limited/regulated by availability of phosphorus, as its water contain nitrogen.

Nitrogen & its forms : Common sources of nitrogen inputs (both autochthonous and allochthonous) into lake ecosystems are (1) atmosphere (precipitation) and (2) inflows (surface, drainage and ground water)–region limestone (Wetzel, 1983). Contrastingly, nitrogen loses are due to (i) effluent outflows (ii) reduction/bacterial nutrification and (iii) permanent sedimentation.

Total or organic nitrogen, was estimated using micro-Kjeldahl's digestion procedure, and interestingly enough, exhibits seasonality, and was only detected in subsurface water samples collected during south-west monsoons, varying between 0.0-4.48 mg/L and apparently owes its origin to small phytoplanktonic algae (Wetzel, 1983). It showed spatial variation in littoral trophogenic subsurface waters, varying from 1.12 mg/L (S_1-Wier level) to 2.24-4.48 mg/L at other sampling sites rich in aquatic vegetation (submerged, floating, rooted plants, *etc.*). Nitrate nitrogen (NO_2-N) concentrations, often the most common inorganic form in natural waters, were absent–6.5 mg/L (summer season) indicating absence of pollution in the raw water reservoir due to sewage and or agricultural run off. Nitrates, being important plant nutrients, promote eutrophication, their low concentrations, 5-8 mg/L, were detected during summer season whereas their absence in samples from other seasons , indicates nutrient poor or oligotrophic status of the raw water reservoir and absence of pollution (NO_3-N concentrations range from 0-10 mg/L in unpolluted fresh waters, Wetzel, 1983).

Ammonia Nitrogen (NH_4-N) : The generation and distribution of ammonia in different freshwaters is known to exhibit highly variable pattern, regionally indeed both seasonally and spatially in different lake ecosystems, depending upon their productivity and amount of pollution from organic wastes. No ammonia nitrogen values were recorded from the reservoir indicting its absence in raw water reservoir. Generally, concentrations of NH_4-N well oxygenated in trophogenic epilimnion are low (<1 mg/L) as it is quickly assimilated by algae (Liao & Lean, 1978). NH_4-N was totally absent in surficial waters in the reservoir, althrough the period of study and further augurs well as clear indicator of absence of any degree of pollution of the reservoir by organic matter. Indeed, its absence, is also indicative of the unproductive nature, following poor nutrient level/concentrations or oligotrophic status of the waters.

Sulphur : Sulphur was estimated both as hydrogen sulphide (H_2S), reduced sulphur, and as sulphates. Incidentally, the different forms of sulphur are well within the permissible limits (absent to 600 mg/L) and ranged between 0.8-2.4 SO_4 mg/L with average of 30 mg SO_4/mg/L (range 20-40 SO_4 mg/L) in raw water reservoir during summer season. The known world range is 5-30 mg/L in different lake ecosystems (Wetzel, 1983). Low sulphate concentration in most lake waters are known to limit algal growth (*e.g.* Lake Victoria, Africa, : Fish, 1956) and perhaps may also in association with other major nutrients *viz.* phosphorous and nitrogen, restrict and or limit phytoplankton growth in Adra reservoir.

Silica : Silica was not estimated for samples for rainy season by oversight, but data for winters (7-15 SiO_2 mg/L) and summers (20-35 SiO_2 mg/L) do indicate an understandable seasonal pattern, besides spatial variations in its concentration. The year round range of values –7 to 35 SiO_2 mg /L and or mean 17 mg/L are well within the known range (1-30 SiO_2 mg/L). In fact, the seasonal trend too is in accordance with universal pattern of rise witnessed in soluble silica in summer season, often in inverse proportion to diatom populations (Lund, 1964). Diatom population in

plankton samples were indeed poor. Saxena, 1982 records similar high concentration but observed poor diatom population. The oligotrophic reservoir supports no algal bloom and indeed is less productive biologically.

ZOOPLANKTON COMMUNITY : COMPOSITION AND STRUCTURE

The zooplankton density is sparse and is mainly composed of copepods (7 spp.), rotifers (10 spp.), cladocerans (13 spp.) and ostracods, in order of numerical abundance, quantitatively accounting for 67.98%, 15.02%, 8.75% and 8.25% respectively. The over all zooplankton diversity of different constituents may be regarded as fair, in line with the status (raw water) and aesthetic qualities of the reservoir–clean, clear, transparent, unproductive *etc.* The zooplankton species are mostly characteristic of clean water and indicates healthy environment.

Table-3. Systematic Inventory of different wetland faunal groups in habiting raw water reservoir, Adra, Purulia District, West Bengal.

Class ROTIFERA*

Subclass EUROTATORIA

Superorder MONOGONONTA

Order PLOIMIDA

Family BRACHIONIDAE

Brachionus patulus Muller, 1786

Keratella cochlearis (Gosse, 1851)

Keratella quadrata (Muller, 1786)

Family MYTILINIDAE

Mytilina ventralis (Ehrenberg, 1832)

Family LECANIDAE

Lecane bulla (Gosse, 1851)

Lecane hamata (Stokes, 1896)

Lecane lunaris (Ehrenberg, 1832)

Family TRICHOCERCIDAE

Trichocerca (Trichocerca) pusilla (Laterborn, 1898)

Trichocerca (Diurella) similis (Wierzejski, 1893)

Family GASTROPODIDAE

Ascomorpha ovalis (Bergendal, 1892)

CLADOCERA**

Family SIDIDAE, Baird 1850

Diaphanosoma excism Sars, 1885

Family MOINIDAE, Goulden, 1968

Moina brachiata (Jurine, 1820)

Family BOSMINIDAE, Sars, 1865

Bosmina longirostris (O.F. Muller, 1776)

Family MACROTHRICIDAE, Norman & Brady, 1867

Macrothrix spinosa King, 1853

M. laticornis (Jurine, 1820)

Echinisca triserialis (Brady, 1886)

Family CHYDORIDAE, Stebbing, 1902

Subfamily CHYDORINAE, Stebbing, 1902

Chydorus sphaericus (O.F. Muller, 1776)

C. parvus (Daday, 1898)

C. barroisi Richard, 1894b

Subfamily ALONINAE Frey, 1967

Alona quadrangularis (O.F. Muller, 1776)

A. rectangula rectangula Sars, 1862

A. rectangula richardi (Stingelin, 1895)

Acroperus harpae (Baird, 1834)

**(Chandrasekhar, 2004)

COPEPODA

Class MAXILLOPODA

Subclass COPEPODA

Order CALANOIDA

Family DIAPTOMIDAE

Subfamily DIAPTOMINAE

Heliodiaptomus sp.

Phyllodiaptomus sp.

Paradiaptomus sp.

Neodiapatomus diaphorus Kiefer

Order CYCLOPOIDA

Family CYCLOPIDAE

Subfamily EUCYCLOPINAE

Mesocyclops hyalinus (Rehberg)

M. leuckarti (Claus)

Annelida : *Scolopendra* sp.

Aquatic insects : *Ranatra* sp.

Mollusca : *Lymnia (pseudosuccenia) acuminata* (Lam.)

Bellamya bengalensis (Lam.)

Bellamya dissimilis (Mueller)

Pila virens (Lam.)

Parreysia sp.

Pisces **

Brachydanio rerio (Ham-Buch)

Rasbora rasbora (Ham-Buch)

Heteropneustes fossilis (Bloch)

Glossogobius giuris (Ham-Buch)

Channa punctatus (Bloch)

Polycanthus fasciatus (Bloch & Sch.)

Mastacembalus armatus (Lacepede)

Amphibia

Rana cyanophlyctis Schneider

*Chandrasekhar and Siddiqi, 2008

**Chandrasekhar, 2003

***Chandrasekhar, 2004

SUMMARY

Adra reservoir (locally named 'Saheb bandh'), is a small raw water, man-made freshwater tank with catchment area of 4.18 sq. kms., full tank level/(FTL) or Full Reservoir Level (FRL) 550.55 ft. basically caters to the primary drinking and secondary uses for the small railway township and workshop at Adra Railway Division headquarters, Purulia District, West Bengal. The relatively small, shallow, freshwater lake located in serene, rural surrounding with reserve forests and territorial army unit, is a placid, clean, aesthetically good looking aquatic environ with small population of waterfowl and minor forms of wetland fauna besides few aquatic submerged/free floating aquatic plants.

The year long field study covering three main seasons, beginning October, 1996-April, 1997, first on the limnological profile, besides evaluating the overall aesthetic and chemical water quality and its suitability for drinking water purposes, attempts an inventory of its aquatic life forms-zooplankton community, littoral and associated wetland fauna, including fish and bird nekton. Based upon average annual range of values of conservative chemical parameters like the different forms of inorganic plant nutrients-Phosphorus (P) and Nitrogen (N), overall physico-chemical and biological *milieu*, the reservoir may be ecologically categorized as *oligotrophic* (nutrient poor) and chemical raw water quality as clean and safe, fit for consumption after due conventional water treatment. The wetland faunal diversity may be regarded as fair and diverse.

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