microbiota from the Deoban Group represent a highly diversified assemblage (a record of over twenty-two taxa) whereas the microbiota from the Jammu Limestone[17] although limited in number, represent quite an evolved community. A cursory comparison of all the three assemblages suggests that the Deoban micro-floristic community possibly represents slightly younger elements in comparison to those from the Shali succession, and those from the Jammu Limestone may still go higher up in the evolutionary ladder. It is therefore suggested that amongst the several terrains of the Lesser Himalayan Inner Sedimentary Belt, the coeval nature of the various sequences needs re-examination for their regional correlation which should be based on a firm biostratigraphic scheme.

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The effect of physico-chemical parameters on the erosion of monumental stones of Orissa

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Old stone monuments situated in Bhubaneswar, capital city of Orissa. India, were built during 7th century A.D. to 11th century A.D., using sand stones of Gondwana age. The present study deals with the effects of various physico-chemical parameters on the erosion of a variety of sandstones used in the construction of these monuments. Experiments were carried out to study leaching of these stones under neutral and acidic media and the salt attack tests performed under controlled conditions in the laboratory. The results of these studies will help to provide an effective method of protecting these old stone monuments from environmental deterioration due to various physico-chemical parameters.

THE temple city of India, Bhubaneswar abounds with hundreds of temples of cultural heritage. These temples are built up of blocks of sandstone of Gondwana age. All the temples constructed between 7th and 11th century A.D. are built up of varieties of siliceous and ferruginous sandstones. Visual observations showed that different stone blocks on a particular face of a monument, exposed to similar environmental condition, have weathered to varying degrees. This shows that pattern of weathering and resistance of the stones towards weathering conditions, change with the variety of stones used.

A detailed survey carried out on all the stone monuments present at Bhubaneswar revealed that three varieties of stones were predominant: red, white and yellow. While the red and yellow varieties, which were locally known as Rajarania were mostly medium grained, the white variety was found both in coarse and fine grained, of which the fine grained was more widely used.

Mineralogically all the three stones can be classified as sublithic arenites. Petrological studies showed that these stones were dominant in quartz and feldspar. Heavy minerals like zircon were noticed apart from opaque minerals. The cementing material was mostly ferruginous and not calcic[1] (the stones failed to give effervesence with concentrated HCl).

Based on the results of this study, three sandstones (red, yellow and white) were identified for carrying out experiments under simulated conditions in the laboratory.

A study conducted[2] on the quality of rain water at Bhubaneswar revealed that the ions precipitated from the atmosphere of Bhubaneswar were NO_3^-, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, K^+, etc. A well-known source of most of these ions is the Bay of Bengal (about 30 km towards east of Bhubaneswar) while the NO_3^- ion is mainly produced from the oxides of nitrogen[3]. The formation of NO_3^- in the atmosphere indicates clearly the chances of formation of micro quantities of nitric acid (HNO_3) during the oxidation step[4,5]. Acidic conditions are also created by some autotrophic bacteria, which produce HNO_3. Biodeteriogens such as fungi[6,7] and lichens[8,9] present on the monuments of Bhubaneswar, are also known to produce organic acids.

Therefore it is clear that these monuments are affected by a combination of natural and man-made environmental factors termed as physico-chemical parameters. The natural factors involve the variation in temperature, water, sand-laden air, precipitation of sea salts from the atmosphere and the acidic conditions created by the biodeteriogens on the stone surface.

The man-made sources generally involve the wet and dry deposition of the pollutant gases on the stone surface. The main source of these gases at Bhubaneswar is the vehicular traffic and to a lesser extent the emissions from a few industries located at a distance of about 20 to 25 km from the city.

Hence keeping in view the above-discussed environmental conditions to which the monuments of Orissa (particularly at Bhubaneswar) are exposed, various laboratory experiments were performed on the three selected monumental stones. Salt attack tests and the leaching tests under acidic and neutral conditions were conducted. All the experiments were conducted under accelerated weathering conditions.

To determine resistant characteristics of monumental stones towards various salts from the atmosphere, salt attack tests were conducted on the three varieties of stones. The procedure adopted for the salt attack test was similar to Esbert's[10].

The preweighed stone cubes $(4 \times 4 \times 4)$ cm^3 were immersed in 14% solution of Na_2SO_4 for 2 h at 24°C. The stones were then removed from the solution and dried at 100°C for 21 h, followed by cooling to room temperature for 1 h. This process formed one cycle. Twelve such cycles were carried out with each stone. After each cycle, the weight was determined and the difference in weight was noted. The above experiment was further extended to study the effect of NaCl and $NaNO_3$ salts. The curves showing the cumulative percent loss in weight of the stone samples, have been presented in Figure 1.

To study the behaviour of the monumental stones towards acidic and neutral leaching conditions, leaching experiments were conducted on the three varieties of stones by adopting the following procedure.

The stone samples $(4 \times 4 \times 4$ $cm^3)$ were immersed in 0.1 N, 0.01 N and 0.001 N nitric acid solutions for varying periods of time, with intermittent drying at 100°C for 21 h between each immersion. The solutions were then evaporated to dryness, made up with distilled water and analysed for parameters like SiO_2 aluminium, sodium, potassium, calcium, magnesium and iron, by adopting standard procedures[11].

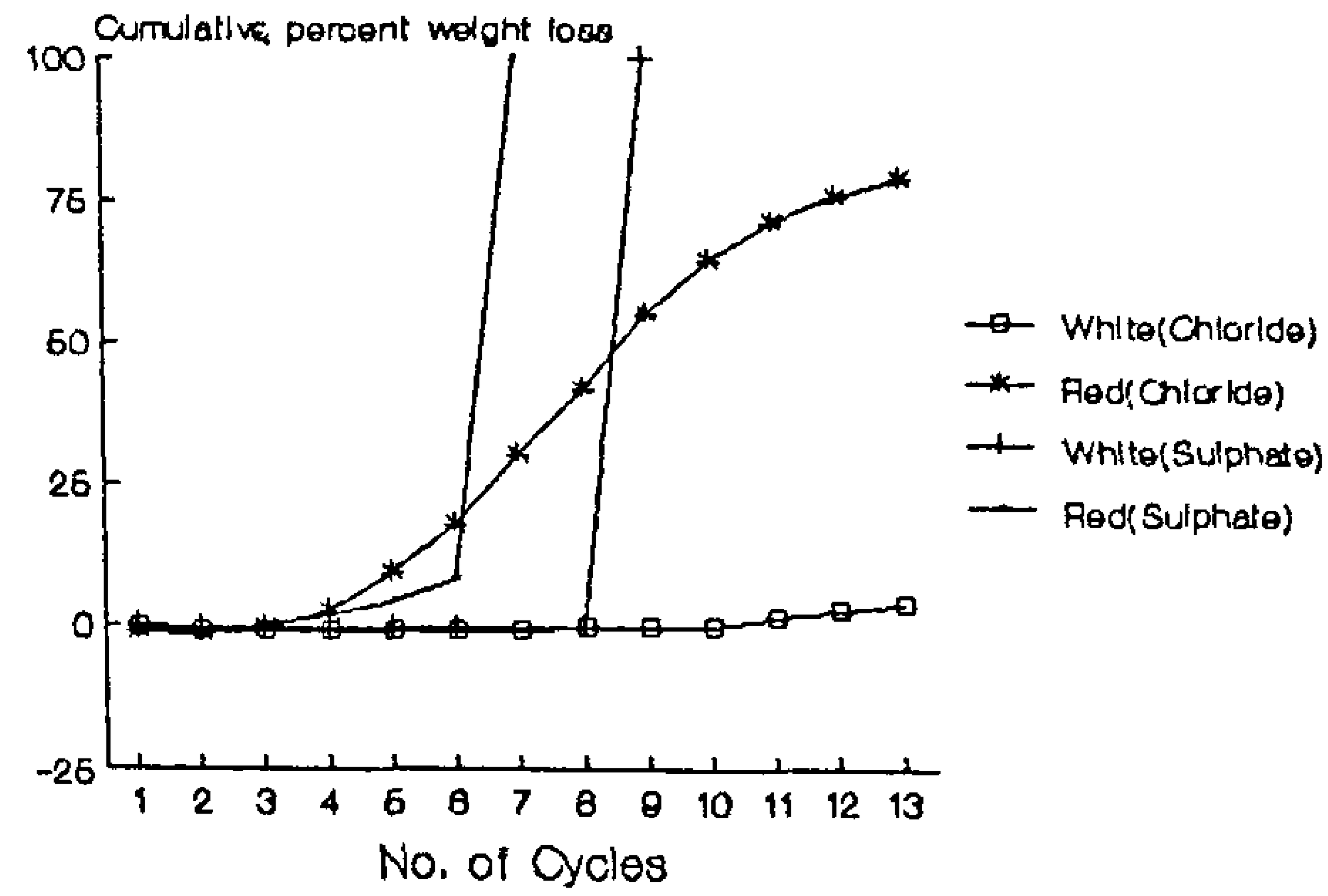

Figure 1. Effect of sulphate and chloride salts on red and white variety stones.

The above experiment was repeated using distilled water. The periods of immersion in both the above experiments were 2, 4, 6, 12, 20, 30, 50, 100 h respectively. The amount of SiO_2, iron and aluminium leached out is presented in Table 1. Physical properties such as porosity, water imbibition and bulk density were determined for all the three types of stones according to the procedures followed by Michela[12].

The results of the salt attack test on the red, yellow and white stones indicate that Na_2SO_4 was the most damaging salt among the three. The red variety was completely destroyed at the end of the 7th cycle. The white variety on the other hand, was destroyed in the 9th cycle of the sulphate attack test, while the yellow stone was intact except for slight weight loss. Chloride attack test was seen to reduce the $4 \times 4 \times 4$ cm^3 stone specimen of red variety to a small sphere. Exfoliations were observed regularly in case of white stone tested with 14% NaCl solution. Sodium nitrate had almost negligible effect on the stones.

The values of physical properties of the stone specimens given in Table 2 show that red and white variety of stones have higher porosity and water imbibition than the yellow stone. This probably enables penetration of greater amount of salt in the pores of red and white stones, thus rupturing the stones. The rupturing takes place due to loss of mechanical strength of the stone, mainly caused by crystallization of higher hydrates of the salts within the pores[10]. The above discussion indicates that yellow stone with a lower porosity and water imbibition of 8.9% and 5.18% respectively, is the most resistant to salt attack. The red stone having higher porosity and water imbibition of 16.7% and 8.65% respectively, is least resistant of the three stone varieties towards salt attack.

The leaching experiment using distilled water showed that maximum amount of Na^+, K^+ and SiO_2 leached out

Table 1. Amount of leaching in acidic conditions

Parameter	Red variety			Yellow variety			White variety		
Concentration of nitric acid	0.1 N	0.01 N	0.001 N	0.1 N	0.01 N	0.001 N	0.1 N	0.01 N	0.001 N
Aluminium (mg)	0.375	0.191	0.037	0.514	0.228	0.041	0.506	0.295	0.006
Silica (mg) (SiO_2)	4.81	1.58	1.78	3.31	1.362	1.75	3.35	1.73	1.41
Total iron (mg)	0.639	0.077	0.096	0.159	0.259	0.108	0.209	0.141	0.180

Table 2. Comparative values of physical properties

Stone variety	Porosity (%)	Water imbibition (%)	Bulk density (g/cm^3)
Red	16.7	8.65	1.95
Yellow	8.9	5.18	1.76
White	14.2	6.69	2.19

Table 3. Ratio of percentage of element in water to the percentage of element in stone

Stone	Na^+	K^+	SiO_2	Fe^{3+}	Al^{3+}
Red	2.3×10^{-1}	6.6×10^{-3}	3×10^{-5}	5.0×10^{-6}	1.7×10^{-6}
White	4.7×10^{-2}	2.4×10^{-2}	5.5×10^{-5}	4.8×10^{-4}	5.2×10^{-6}
Yellow	7.7×10^{-2}	6×10^{-3}	3.4×10^{-5}	3.6×10^{-4}	1.6×10^{-5}

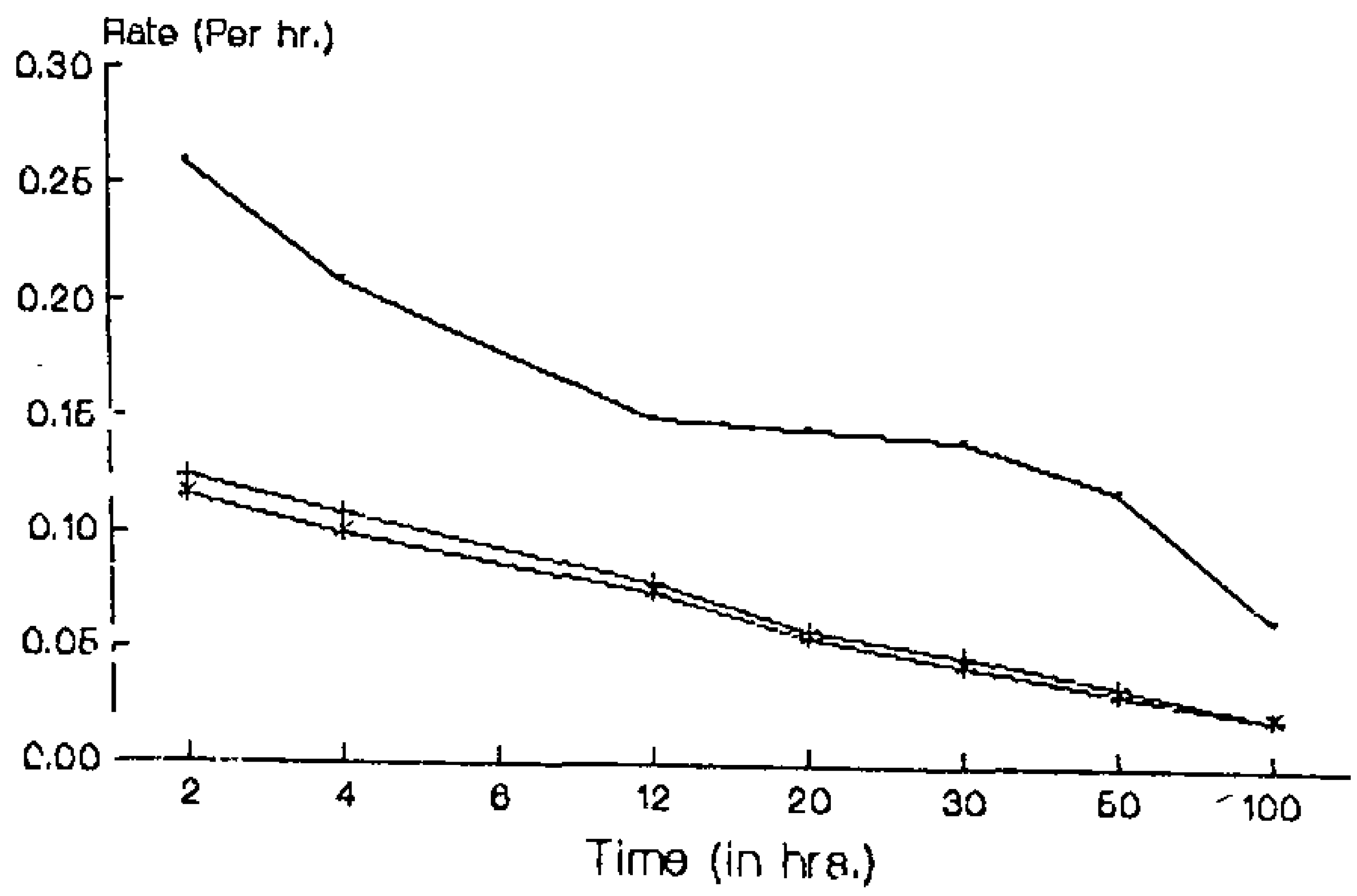

Figure 2. Rate of leaching in neutral condition.

from the red sand stone followed by white and yellow sand stone. The results presented in Table 3, indicate the ratio of the quantity of the substance leached into solution to the quantity present originally in the stone specimen. It is clear that the results project the following ranking with respect to ease of leaching of the elements from the three stones:

Red $Na^+ > K^+ > SiO_2 > Fe^{3+} > Al^{3+}$
Yellow and white $Na^+ > K^+ > Fe^{3+} > SiO_2 > Al^{3+}$

The leaching of ions in distilled water was observed to obey the following equation

$$n(\ln C_A/C_A - C_x) = K.t,$$

where C_A is the initial concentration of ions in solution, C_x the concentration in solution at time t. K the rate constant and n the number of cycles.

The rate constants for total leaching from red, yellow and white stones were found to be 4.7×10^{-3} min^{-1}, 4.4. $\times10^{-3}$ min^{-1} and 4.1×10^{-3} min^{-1} respectively. Rate of leaching showed (Figure 2) that though initially high, a steady state or a constant rate was attained at the end of 100 h of immersion.

Table 4. Cumulative percentage of weight loss of samples in acid leaching

Concentration of HNO_3	Red variety	Yellow variety	White variety
0.1 N	0.0559	0.0235	0.0259
0.01 N	0.0536	0.0235	0.0246
0.001 N	0.0535	0.0204	0.0245

Amount of SiO_2, total iron and aluminium leached out in acidic conditions was relatively high (Table 1) as compared to leaching in distilled water. The results also revealed that maximum weight loss of the stones occurred under 0.1 N HNO_3 (Table 4). Deterioration was maximum of the red and white stones under both acidic and neutral conditions.

From the above observations it is clear that the stone monuments at Bhubaneswar are prone to decay even in the natural environment. Hence conservation measures are essential for the preservation of these ancient monuments.

The main objective of conservation is to remove microorganisms, salts and prevent interaction of rain with the stone surface.

Removal of microorganisms like lichen and fungus can be achieved by applications of aqueous sodium salicylate (1%) or aqueous zinc or magnesium silico fluoride (4%) (ref. 13). Organisms such as moss could be easily removed by 5% ammonium hydroxide[14,15].

The salts deposited within the pores of the stone can easily be removed by the paper pulp technique[16].

Finally during preservation, polymethyl methacrylate was better substituted by Tegovakon V and Organo Silanes[17] although silane appears to darken the colour of the stone to some extent.

From the above study it could be concluded that the three types of monumental stones are extremely vulnerable to attack by the physicochemical parameters. In particular, the red and white variety of stones have less resistance towards saline, acidic and neutral conditions. Hence utmost care should be taken to conserve the old stone monuments which are predominantly built up of the red and white stones. Keeping in view the growing urbanization at Bhubaneswar and the environmental condition in the city, regular removal of the salts from the monumental surface (by paper pulp method) and the use of protective coatings like Tegovakon V and Organo Silane are recommended. Removal of lichens and fungus can be accomplished by the use of 1% sodium salicylate solution or 4% zinc or magnesium silicofluoride solution. 5% ammonium hydroxide solution was most effective in removing moss.

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Errata

Calcutta's industrial pollution: Groundwater arsenic contamination in a residential area and sufferings of people due to industrial effluent discharge – An eight-year study report

D. Chakraborti, G. Samanta, B. K. Mandal, T. Roy Chowdhury, C. R. Chanda, B.K. Biswas, R. K. Dhar, G. K. Basu and K. C. Saha

[*Curr. Sci.*, 1998, **74**, 346–355]

In the first line of the abstract, Parin Green should read as Paris Green. The error is regretted.

Plasmid profile of *Erwinia herbicola* ATCC 21998

S. Koul, V. Verma, Anand Kumar and G. N. Qazi

[*Curr. Sci.*, 1997, **72**, 876–879]

The name of one of the authors, Anand Kumar should read as Anil Kumar. The error is regretted.