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CHEMICAL RESEARCH IN INDIA DURING NINETEENTH CENTURY

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From the very beginning the chemical research in India was carried out in the interest of British industrial and finance capital. This link has been elucidated.

On examining the literature it was found that the total number of research papers on chemistry published in British India was not only small but there was neither any coordination nor any schooling among the research chemists except at the fag end of the century when a nationalistic school appeared. The research was need-based, result-oriented and commercial in nature. The research papers were mainly on the chemical analysis of minerals, water, medicinal plants and its products, chemistry of dyes and soil. The campaign to resort to the Āyurvedic system of medicine resulted in a number of publications relating to the medicinal properties of plants.

The status and the quality of the chemical research in India have been discussed and their relation with the then educational, socio-economic and political state of India explained.

I

The distinctive economic rule of the East India Company was brought to an end with the ending of its monopoly in 1813 and the interest of the British industrialist class in India began to brighten.[1] This stage is the period of industrial capital which established a new basis of exploitation of India, and started its function from the first quarter of the nineteenth century. The British rulers wanted to search for useful raw materials from the huge natural resources in India, so that they could export finished materials of their newly acquired factories—a direct offshoot of the Industrial Revolution—to other European countries and their colonies. India was found to be a vast store house with exotic varieties of flora, fauna and minerals. Therefore, they concentrated their scientific activities on the excavation of minerals and their chemical composition, on the chemical and pharmacological action of the indigenous drugs, *etc.* The chemical research on natural products started with much difficulty. The result was that much of it was of little value. Collections

were made, expeditions described and papers written by men who pretended only to modest scientific background.[2]

The next phase of the British rule in India is the period of finance capital, developing its distinctive system of exploitation of India on the remains of the old, and growing up from its first beginnings in the closing years of the nineteenth century to its fuller development in the early twentieth century.[3] It was necessary to open up India more completely for commercial penetration. This required building of a network of railroads, the development of roads, the introduction of the electric telegraphy, the establishment of an anglicised education to secure a supply of clerks and subordinate agents, and the introduction of European banking system. The British capital steadily began to increase in government and municipal activities, in railways, plantations, mines, banks, and financial institutions. This was the period when the introduction of western science started to operate. At this stage began the struggle by Indians, urged by nationalistic feelings to achieve an independent scientific tradition. Certainly this phase of science differs completely from the colonial science that prevailed in the previous era.

II

The total number of research papers on chemistry published by the researchers in British India during the nineteenth century is very small, especially in comparison to mathematics and geology. There was neither coordination nor schooling of chemistry before the end of the century when Acharya Prafulla Chandra Ray could organise chemistry teaching and research on a small scale in the laboratory of Presidency College, Calcutta.

Analysis of minerals, river water, plant ashes, *etc.* were carried out and the results were published in the Journal of the Asiatic Society. A list of such publications was incorporated by P.N. Bose in the Centenary Review of Asiatic Society (1784-1884).[4] While analysing these publications he observed : "That (Chemistry) is a subject which can be prosecuted only in the laboratory. In India, until recently, there have been but few laboratories worth the name and we have had but few competent men with leisure to devote to length and chemical research".

There were assayers at the Calcutta mint during 1792, when Robert Blake was Assay Master. In 1816 Dr. Horace Hayman Wilson was appointed Assay Master, and in 1833 he was succeeded by James Prinsep after serving several years at the Mint Office at Benares.[5] The assayers and medical men were the earliest of the modern chemists in India, but they were not employed as research officers. James Prinsep wrote some of his many papers on physical science topics, *e.g.*, on hygrometry and pyrometric alloys, and he carried out chemical analysis of natural water and rocks. Apart from Prinsep, J.

Middleton, author of some works on fluorine in bones, was another chemist in the early nineteenth century of India.[6]

H.E. Busteed published in 1870 a paper on the method of assaying silver adopted in the Assay Office in Indian mints.[7] J. Campbell wrote a manual of chemistry in 1842.[8] Chemical analysis of rocks and minerals were necessary for economic reasons. H. Piddington wrote a paper on examination and analysis of some specimens of iron ore from Burdwan in 1829[9], J. Prinsep wrote on analysis of Platina from Avá in 1828[10] and on the analysis of copper ore from Nellore in 1835.[11] In this connection, it can be recalled that curiosity on Indian iron led Michael Faraday to analyse Wootz or Indian steel and develop a steel of stainless variety.[12] H. Piddington separated mercury from gold and silver by distillation (1852). Being an Āyurvedic expert, Dr. Kanailal Dey tested the Indian opium for porphyroxin in 1867. While coal chemicals were being analysed by Perkin in England, Sir Alexander Pedler and Chandra Bhusan Bhaduri analysed coal gas and water supplied in Calcutta in 1875.[13] Regarding alkaloid chemistry, Pedler's research paper on the chemical nature of cobra venom published in the *Journal of the Chemical Society* in 1880 was the first of its kind in India. Probably the first photochemical research in India was performed by Pedler. He studied the action of light on phosphorus, chlorine and chlorine acids and attempted a chemical analysis of some sulphurous gases (1890).[14] Pedler also published a booklet *A memorandum on the corrosion of the lead linings.* In recognition of his tremendous contributions towards advancement of knowledge of chemistry he was made a Fellow of the Royal Society, London in 1889 and he was one of the earlier scientists from India to earn this coveted distinction. In this connection, it may be recalled that Dr. Aghore Nath Chattopadhyay, father of Smt. Sarojini Naidu, had his D.Sc. (Chemistry) of Edinburgh in 1875, the first Indian to have this distinction. When Sir Prafulla Chandra Ray went to Europe for the second time, Van't Hoff asked him if he knew Aghore Nath Chattopadhyay. Aghore Nath by that time had left chemistry and joined the services of the Nizam of Hyderabad.

Chemical analysis of geological specimens in the laboratories of Geological Survey of India under the curatorship of T.H. Holland touched real heights in the late nineteenth century. It was reported that while, during 1882-90, the average number of specimens analysed was about 50 a year, it was 790 during 1903-08. Holland also helped Sir P.C. Ray in analysing the rock and mineral in the Presidency College laboratory, Calcutta. Ray was interested to discover one or two new elements that may fill up the gaps of the Periodic Table.[15] Indian coal was analysed in the English laboratories. To determine the quality, Oldham of the Survey sent few specimens of the principal coal beds to the International Exhibition in London in 1862, where it was found that the Indian coal contained 52.5% carbon, 31.9% volatile matter and 15.5% ash.[16]

There were occassional fire incidents in ship and suitable remedy was

sought. Such need-based research is evident from the publications of H. Piddington. A monogram on *A Cheap, Simple and Certain Method of Early Warning of any Approach to Spontaneous Combustion or Ignition by Accident on Board of Steamers, Coal or Other Ships* was published by him in 1847. David Waldie, who contributed two papers in 1873 on Calcutta Water Supply in the *Journal of The Asiatic Society*, was associated with the discovery of the anesthetic property of chloroform in 1847 as was done by Simpson of Edinburgh independently. The two exchanged correspondence on the subject.[17]

W.B. O'Shaughnessy, the Chemical Examiner of the Government of Bengal and Professor of Chemistry at Medical College, Calcutta, contributed much towards chemical research in the early part of nineteenth century. In 1840, he submitted a report to the government on the enquiries and experiments on native clays and pottery (including the chemical composition of clays of different areas).[18] The Government was eager to replace the imported goods for their high cost. The analysis of clays was performed by Nobin Chunder Paul, an ex-student of Calcutta Medical College. Being a Government Chemical Examiner, O'Shaughnessy had to carry on analysis of forensic materials, *e.g.*, arsenic piosoning, *etc.* in the chemical laboratory of Calcutta Medical College.[19] Once he analysed the cases of poisoning by aconite *(Aconitum ferox of Nepal)*,[20] and bark of *Cinchona excelsa* from the Botanic Garden of Calcutta.[21] When Indian Association for the Cultivation of Science was established by Dr. M.L. Sircar in 1876, Dr. Chunilal Bose started a teaching class there on commercial chemical analysis.[22] He submitted a scheme on this subject. His scheme proposed to provide training for special analysis of water, milk, butter, ghee, flour, sugar, meat and other foodstuffs, vegetables, mineral oils, liquors, drugs, indigo and other dyestuffs, and substances used in various arts and manufactures. The proposal was readily accepted and the class was opened. Even Sir P.C. Ray was engaged in determining adulteration of foodstuffs.[23] The results were published in the *Journal of the Asiatic Society of Bengal.*

In the early part of the nineteenth century, a vigorous campaign was started for resorting to the old system of Āyurvedic medicine. William Jones, John Fleming, W. Roxburgh, W. Ainslie and others were active participants. They published several books on medicinal herbs of India. The Europeans themselves were interested in Āyurvedic drugs. It was Sir William Jones who wrote the first article, "On the cure of elephantiasis and other disorders of the blood" in 1785, being a translation from the Sanskrit Original, and "The design of a treatise on the plants of India" in 1789. Richard Miller wrote in 1811 his *Disquisitions in the History of Medicine* devoting a section to the conditions of healing in Hindusthan. In 1823, H.H. Wilson wrote an article entitled "On the Medical and Surgical Sciences of the Hindus.[24] The most commendable work of the nineteenth century on the chemical composition and pharmacological

action of the drugs was *Pharmacographia Indica.* In this book, in addition to their own work, Dymock, Warden and Hooper (1890-1893) included the work done by other scientists upto that time. The first English book which exclusively dealt with the properties and uses of Āyurvedic drugs was of O'Shaughnessy (1841). This was followed by Dey's (1867) *Indigenous Drugs in India* and in 1868 Waring published his *Pharmacopoeia of India* followed by Mohideen Sheriff's supplement to it in 1869. The chemical and physiological examinations of Indian herbs and drugs were recorded in 1840 in *Bengal Pharmacopoeia.*[25] Later on Dutt (1877) wrote Āyurvedic properties of drugs in English, which further aroused the interest of the European scientists in the subject. Therefore, the history of drugs in the form of *Pharmacographia* was written by Fluckiger and Hanbury (1879), and Dymock (1883) wrote *Vegetable Materials of Western India.* When Sir P.C. Ray visited Paris there he met M. Palmjer Cordier, a medical officer in service in French India, who wrote treatises on Indian medicine, based on Buddhist literature.[26] The first Indian Medical Congress was held in 1894 at Calcutta and many papers on identification, chemical composition, pahrmacological and chemical actions of the indigeneous drugs were read by European and Indian scientists.

The first chemist to investigate plant products in India was W.B.O'Shaughnessy (1841) of Calcutta Medical College. Studies on the medicinal and poisonous plants of India were later undertaken with right earnest in the same institution by Warden and Hooper and they were the first to isolate arbin, a toxic protein, the poisonous principle of *Arbusprecatorius* (Kunch).[27] W.B.O'Shaughnessy published *The Bengal Dispensatory and Pharmacopoeia* and *The Bengal Pharmacopoeia* in 1841 and 1844, respectively, wherein he described the chemical composition and method of preparation of Indian drugs of his time. To minimise the cost Dr. O'Shaughnessy recommended the use of the leachings of native magnesium limestone instead of imported sulphate of magnesia.[28] For the assistance of persons desirous of preparing pyroligneous acid in India, Dr. O'Shaughnessy described his personal research experience on the manufacture of the acid. He worked on a government project on manufacturing the acid in 1838.[29] These two books were the guides to the preparation of the remedies usually employed in the medical practice of Bengal.

Mr. Hallen, a trained weaving specialist invented the world famous *khaki* colour in 1851.[30] Lord Roberts, who visited the weaving establishment at Karnataka at that time, was so pleased with this natural ground colour that his earnest advocacy of its use has made it the colour of uniform of the British army the world over. In order to search for new vegetable dyes E.J. Hill of Allahabad University isolated the colouring matter of *Nyctanthes carbortristis* Linn. in 1896 and studied its properties.[31] Valuable research on natural products was carried out at Bangalore, Madras, the Forst Research Institute of

Dehra Dun, Dacca, Calcutta and Ranchi. Chunilal Bose carried out research on the chemistry of *Nerium odorum* and published his paper in the *Journal of the Chemical Society*.[32] The bark of kurchi *(Holarrhena antidysenterica)* was used by Sir P.C. Ray as one of the principal ingredients of a medicine prepared in his Bengal Chemical factory. The medicine was used as antidysentry, antidiarrhoea and as a cure for fever, piles, leprosy and diseases of spleen. Later Ghosh and Ghosh isolated three alkaloids conessine, kurchine and kurchicine in the bark of kurchi.[33]

The early era of Biochemistry is seen in 1894, when Dr. Nilratan Sarkar agreed to give gratuitous lectures on Physiological Chemistry in the Indian Association for the Cultivation of Science.[34] He held classes for about two years, lecturing on the proteins, their reactions and classifications, the chemistry of several proteins and the alkali albumins, globulins and peptones.

Throughout the nineteenth century, chemistry was essentially feeling its way, concentrating on the purification of natural substances and on their analysis. But the trend of the chemical research was changing slowly. It was in 1886 that postgraduate teaching in chemistry was introduced for the first time in India, a new chemical laboratory was set up in 1893 at the Presidency College, Calcutta and was properly equipped with imported instruments. Here, in the rooms of Presidency College, we saw the dawn of pure chemical research, thanks to the acumen of Sir Alexander Pedler, the pioneer of modern chemical research in India, and subsequently of Acharya Prafulla Chandra Ray. P.C. Ray published his first work from the Presidency College on "Conjugated Sulphates and Isomorphous Mixtures of Copper-Magnesium Group" in 1891.[35] In continuation of his interest in photochemistry Pedler published research papers in the *Journal of the Asiatic Society of Bengal* in 1895 and 1899 under the titles "Notes on the Bleaching Action of Light on Colouring Matters"[36] and "On the Volatility of Some of the Compounds of Mercury and of the Metal itself",[37] respectively. He, along with J.B. Bhaduri submitted a note on the action of nitric oxide on alkali in the Journal in 1896.[38]

The first notable work of Sir P.C. Ray which brought him recognition was the isolation of mercurous nitrite in 1895. While he was busy, on one occasion, to prepare mercurous nitrate by the action of cold and dilute nitric acid on mercury, he suddenly discovered the formation of bright yellow crystals of mercurous nitrite. It may be recalled that few years before the discovery of mercurous nitrite, Ray was busy in studying the metallic preparations given in U.C. Dutt's *Materia Medicas of the Hindus* for the preparation of drugs in Bengal Chemical factory. His curiosity prompted him to read some of the original Sanskrit works quoted in this pioneer book. Thus ancient chemistry might have been at the back of his mind when he started to prepare compounds of mercury. Subsequently, Ray became interested in Hindu chemistry and wrote two volumes on the *History of Hindu Chemistry*. He also published the

Rasarnavam or the ocean of mercury and other metals and mienrals.[39] Ray always acknowledged the help and guidance of the great French chemist Berthelot in his study of the history of chemistry. He also studied the stabilities of metallic nitrites and hyponitrites and the action of nitric acid on metals in his early career. Between July 1895 and May 1897, Sir P.C. Ray and his associates published eleven papers in Indian and overseas journals.[40] The discovery of mercurous nitrite created an electrifying effect among the European chemists. The appreciative and congratulatory letters from eminent chemists like Roscoe, Divers, Berthelot, Victor Meyer, Volhard and others stimulated Ray for his further activity with nitrites. During his second trip to Europe in the early twentieth century, Ray met Ramsay, Van't Hoff, Berthelot, Dewar, Perkin, *etc.* These meetings were much helpful for a young chemist from a colonial country. For his enormous contribution towards the chemistry of nitrites, P.C. Ray was designated by Prof. Armstrong as the 'Master of Nitrites'. From the laboratories of the Indian Association for the Cultivation of Science, the first report of the original scientific investigation was by Dr. Sarasilal Sircar, Assistant Chemical Examiner to the Government of Bengal.[41] His work was on the properties of crystalline copper ferrocyanide for which he was awarded the Elliot Prize. In searching new organic colour Sircar investigated the colouring matter obtained in the Ruttee seeds (*Abrus precatorinsi*). Next to P.C. Ray were the Bhaduri brothers—Chandra Bhusan and Jyoti Bhusan—who pursued their work from 1898. In 1893, Werner put forward his theory on complex compounds. This inspired the Bhaduri brothers to study the properties of the complexes. Their work was broadly divided into studies of certain complex inorganic salts like copper-alkali-ferrocyanide, sodium-silver thiosulphate, *etc.*, and the examination of the constituents of some drugs like *Andrographis paniculata, Ocimum pilosum, etc.*[42] Jyoti Bhusan Bhaduri published his Elliot Prize essay on the transformation of hypochlorites to chlorates in the *Journal of the Asiatic Society of Bengal* in 1896.[43] In the same year another note on the decomposition of mercurous chloride and estimation of chlorine was published by him in the same journal.[44] Probably P.C. Ray's discovery of mercurous nitrite influenced Bhaduri in carrying out research with mercury compounds. In 1898, the Bhaduri brothers wrote a research paper on double thiosulphates of cobalt and nickel in the Journal of the Asiatic Society.[45] Another paper with the title 'Notes on new salts of cobalt and nickel' appeared in the Journal in 1896. The author of the paper was Nagendra Chandra Nag.[46] In physical chemistry some original research was made by an Assamese scientist, Mr. R.D. Phookan. The results of these investigations were published in German Scientific periodicals. Phookan also worked on stereochemistry being perhaps influenced by the discovery of Van't Hoff and Le Bel in 1874 of asymmetry of the carbon atom. He published the paper "On the rate of evaporation of bodies in atmosphere of different densities.[47]

Sir J.L. Simonsen had started research in organic chemistry in the Presidency College, Madras, but he did not stay long enough to create a strong school of chemistry there.

III

While the introduction of western sciences to India was extremely tardy and hardly noticeable until the closing years of the nineteenth century, it is quite understandable why only a few Indian chemists were involved in original research activity.

There was very little scope of being well-equipped and trained in chemistry even at the end of nineteenth century. Calcutta University was not a teaching institute till 1917. Among the early institutions where the training of chemistry began was Presidency College, Calcutta. The study of chemistry at the Presidency College was first introduced in 1872-73. It was in 1886 that postgraduate teaching in chemistry was introduced for the first time in India in the Presidency College of Calcutta, when only three students passed with the Master's Degree in Chemistry in 1888.[48] The Indian Association for the Cultivation of Science, that came into existence in 1876, made arrangement for lectures in Chemistry. Slowly the original research chemists began to appear. Researches in the various disciplines of chemistry, *i.e.*, inorganic, physical and organic were started by Sir P.C. Ray, Dr. N.R. Dhar and Dr. J.L. Simonsen, respectively.[49]

The growth of science generally depends to a large extent on the socio-economic factors of a country. In the situation that prevailed then in India, field sciences were developed by the British because of the economic returns they ensured, but not the basic science like Chemistry. The ruling class discouraged Indians to pursue science activities. The Indian Advisory Committee which was formed in 1898 by the Royal Society to advise the Government on the problems of sciences in India held that the scientists in India should leave pure science to the British and acquaint themselves with the applications of science.[50] There are evidences to suggest that students of European and Anglo-Indian origin were preferred for science education. In 1864, for instance, an official proposal came to make available works on science and literature for European students.[51] The British outlook was quite clear from the fact that while in 1881, the French held a meeting of their Association for Advancement of Science at Algiers, their colony, their British counterparts never thought of holding a scientific meet in India.[52] In 1896, the Gilchrist Educational Trust had to withdraw their Indian Scholarships, because their scholars never succeeded in getting adequate employment under Government of India.[53]

The British nineteenth century industrial monopoly and domination of world market began to weaken in the fourth quarter of the nineteenth century. In the other parts of the world the decline in contrast to the new European (especially Germany) and American rivals, was marked. In India, the decline was, however, far slower. In the five years 1874-79, the British share of Indian imports was 82 per cent, which came down to 66 per cent by 1899-1904.[54] Thus, the British capital dwindled and the finance-capitalist exploitation of India started slowly. Again, the process of British capitalist investment in India did not by any means imply a development of modern industry in India, but major capital was devoted to purposes of government, transport, plantation and finance. The major industries of the late-nineteenth century, such as electricity, steel, coal and petroleum did not flourish in India in due time. The chemical industry that was based on the synthetic products of coal and petroleum found no place in the industrial map of India. All these influenced the nature and status of the chemical research. Though independent and curiosity oriented research began at the end of the last century, its quality and hence social impact were far below the international standard. The situation, however, slowly changed at the beginning of the present century when a powerful school of chemistry led by Acharya P.C. Ray with such devoted and nationalist minded followers like R.L. Dutta, H.K. Sen, B.B. Dey, J.N. Rakshit, N.R. Dhar, J.C. Ghosh, J.N. Mukherjee, P. Ray and others started their individual careers. Thus was established the solid foundation of chemical research in India.

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