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On the History of Water Coagulation - Transfer of Ancient Hindu Practices to the Valleys of the Yangtze River and the Nile

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Introduction

Water coagulation is one of the standard methods used by modern water works for the treatment of drinking and waste water. Most laymen and engineers in the Western world believe that this technology was invented by Europeans sometime in the 19th or early 20th century. However, in tropical developing countries, the clarification of turbid waters from rivers, lakes and water holes is an old household method, although only a few traditional materials act as primary coagulants. Seeds of *Moringa oleifera* containing basic poplypeptides are currently the most promising plant material for utilisation in water supplies. These seeds were detected by Sudan Arab village women at the beginning of the 20th century as substitutes for less efficient beans and groundnuts (Jahn 1981 and 1986). The oldest records of a precursor of these seeds are from ancient India (1st century A.D.). European eyewitnesses reported related water clarification methods in Egypt at the end of the 16th century and China at the end of the 17th century (Baker 1948: 300,302). Striking similarities between the Indian and Egyptian methods of applying a flocculating plant material have already been pointed out (Jahn 1988a: 172), but historical data from Chinese archives have not been considered to date. According to some notes, the author recently obtained from Beijing and Taipei, attempts at water clarification have been reported in China since the 2nd century A.D. The present paper aims at investigating how the Chinese were involved in the transfer of knowledge and contributed to new developments. The work is based on studies of literature, correspondence with historians, and laboratory and field research on traditional water coagulation in the Sudan and other tropical countries in Africa, Asia and Latin America. The historical data are critically analysed from various points of view. Special attention has been paid to the role of religions, their codes of law and local concepts of water treatment. The transliteration of Sanscrit, Arabic and Mandarin is done in various ways. In the present paper it corresponds to the method used by the authors quoted or the informants in their books, articles or personal communications, but special phonetic signs have been omitted to avoid difficulties in printing. As far as Chinese words are concerned, the different systems of transliteration can be compared in a guide by Legeza (1968-69).

Early References to Traditional Clarification with Plant Materials

Water clarification with kataka seeds in Hindu and Buddhist scriptures

The first detailed reference to Hindu practices of clarifying water with "coagulants" of plant and mineral materials is made in the *Sushruta samhita*. This famous treatise, written by Sushruta, is believed to be based on the divine teaching

revealed to the holy Dhavantari, the greatest of all healers, who offers the ambrosia of immortality to the gods. The oral traditions may go back several centuries B.C., but no written documentation exists before the beginning of the first century A.D. (von Hinüber: personal communication). Sushruta starts to describe how the qualities of the "ambrosial rainwater" change after it has fallen into different types of receptacle on the surface of the earth (rivers, tanks, ponds or fountains), and how it can become contaminated by soil and plants (= probably a reference to algae and microbes). Among his words of advice on how to avoid diseases caused by consumption of unwholesome water he says:

> There are seven modes of purifying water such as by immersing the *kataka* fruits, the gems known as the Gomedha, the roots of lotus plants, or aquatic mosses, a piece of linen or a pearl or a crystal in a pitcher or vessel containing it (Bishagratna, part 1: 424).

The identification of most of these materials has been rather controversial. Only the first was easily recognizable. *Kataka* is the Sanscrit name for *Strychnos potatorum* L.[1] In the ancient Hindu law codex attributed to Manu (*Manu Smriti* or *Manu-samhita*, aboutA.D.100-300), traditional water clarification with seeds of *Strychnos potatorum* is mentioned in 6.67 as a philosophical hint:

> Though the kataka tree's fruit makes water clear, water does not become limpid merely by the mention of its name (Apte: 526).[2]

Further quotations can be found in the *Advaita Vedanta*, philosophic interpretations of Vedic scriptures which were attributed to the famous thinker Samkara and his contemporaries, such as Suresvara and Mandana Misra. Although they are dated between A.D. 680 and 750, their philosophical ideas are unlikely to have been completely new at the time. Samkara actually referred to much older traditions (Potter: 9,18). When pointing out ways of achieving liberation from rebirth and the bondage of ignorance, the said philosophers usually present their arguments in the form of dialogues between scholars, or a teacher and his disciples. In this context, they also use water clarification with the seeds of *Strychnos potatorum* in comparisons. They were obviously impressed not only by the remarkable ability of ground *kataka* "nuts"[3] to remove all the "dirt" when they were added to "dirty water", but also by the fact that the seeds disappeared in the process. The following analogies are drawn:

> Any set of causal conditions can remove *avidya* (=ignorance) completely without leaving anything else foreign to the Self (to be understood also as: reality or Brahman) in its place (Mandana Misra, Potter: 43).

> The Self who was detached in dream becomes tranquil in deep sleep. Like water purified by the *kataka* nut, the Self when rid of all impressions (*bhavana*) of *samsara* (=bondage of rebirth) becomes clear. No *vasanas* (=subconscious impressions) are brought to the deep-sleep state (Suresvara,Potter: 90,501).

> The *jiva* (a person having false imagination regarding real things) tainted with ignorance but having made pure by repetition of his knowledge (*jnanabhyasa*), dies of itself as the clearing-nut does in water (Samkara, Potter: 323).

> The means (such as listening to Upanishadic texts or meditation), even though they involve difference, destroy other differences before disappearing themselves, leaving nothing but pure Brahman. It is like the powder made from a certain nut (*kataka*) which precipitates other dust from water before itself precipitating (Mandana Misra, Potter: 353-354).

The lawmakers of the Indian Buddhists were also in favour of water coagulation and convinced of the superiority of *kataka* seeds. In the *Samantapasadika*, a comment in Pali on the law texts of the southern Buddhists, compiled about A.D. 500, we find:

> As the *kataka* nut remains separated from the water after clarification (= it will not be consumed together with it), it is taught that its adding to water is legally acceptable.

Apart from this plant coagulant, the *Samantapasadika* knows of the use of another plant material which does not appear in any other texts:

> Water clarified with *kapittha* fruits (*Ferronia elephantum* Correa, rose-apple tree) which are considered as food may be consumed before the meal.

According to Prof. von Hinüber (1980) to whom I owe these two quotations, this legislation meant that Buddhists were allowed to drink water treated with *Strychnos potatorum* seeds at any time, whereas water treated with *Ferronia elephantum* fruits could be consumed only before 12 p.m. When the water had acquired the taste of these fruits, (=the clarification result was less satisfactory!) it was among the foods which were not allowed, by law, to be consumed after noon.

Clarification of water from the Yangtze River with apricot kernels (12th century)

Two historians from Taiwan kindly searched some early references to water coagulants in China for me. In doing so, they found notes from the 2nd, 4th and 10th century A.D. on the use of glue made from animal hides for water from the Yellow River, and a first report on the use of *xing ren* (=apricot kernels, usually translated as "almonds"[4]) by the poet Lu Yu in his "Travel to Sichuan" (Chen and Xiao: 1991). According to an annotated English translation of Lu Yu's *Rushu ji* (= diary of a journey to Sichuan, Chang and Smythe 1981), Lu Yu was a high government official of the Song Dynasty who had been appointed as vice administrator in Fengjie on the Yangtze (Yangzi) River. Accompanied by his sons and attendants he left his former post in Shanyin (modern Shaoxing Xian) in Zhejiang on July 3rd 1170 and reached his destination in Sichuan on December 6th. Apart from official visits to government seats, he spent a great deal of time on excursions to Daoist and Buddhist temples, monasteries and other monuments en route. By the end of July the party had started, in Jinjiang in Jiangsu Province,

to sail on the Yangtze River (Chang and Smythe: 30 ff.). Thus, it was on the great river during the rainy season when turbidity is highest, but most nights were obviously spent on land. Lu Yu (Lu Yü) was a perceptive and critical observer with broad interests and great concern for socio-cultural problems. Thus, he took an interest in the hard lives of the boatsmen, or in women carrying heavy wooden jugs with river water in the gorges, and he was very keen on "water qualities". In the 8th and 9th century, Lu Yu and Liu Bochu (Liu P-ch'u) had already attempted to classify the best waters in the empire for making tea (Chang and Smythe: 60) Some of the wells of highest rank were found in the mountainous regions on either side of the Yangtze River. They had such poetic names as "Jade Milk Well" or "Goddess of Mercy Spring" (Chang and Smythe: 47,108) and were close to temples. Lu Yu seems not only to have enjoyed tea which was prepared with such waters either by friends and officials or by the monks in temple rest houses, but also to have drunk fresh water on several occasions. He also used to observe the shifting colours and the clarity of the lakes, creeks or rivers on his travels. In Book Three he noted on the evening before reaching the town of Jiangzhou at the beginning of September (Chang and Smythe: 98):

> At the entrance to the lake a branch of the river divides off. This is the Nan-chiang (the Southern Yangtze). It is a route to (the region of) Chiang-hsi. The (Yangtze) river water is muddy. Whenever it is drawn for use, it is always settled with almonds [correct translation: apricot kernels!] overnight before it is drinkable. However, the Nan-chiang is absolutely clear. Where the two meet, it is as if a rope was drawn between them, for the two do not mix.

Lu Yu did not express any surprise at water clarification with a plant material. The practice must have been common at the time. We do not know whether he tasted the treated river water. He only mentioned that he enjoyed delicious well waters on his travels and that his hosts gave him bottles of precious waters as gifts.

At the end of the 16th century, Li Shichen compiled his famous Pharmacopeia with quotations from 952 previous authors. It was published in 1596, three years after his death. In this context he pointed out how pure water can become turbid and mentioned plain sedimentation as an alternative method of purification. Furthermore, he confirmed Lu Yu's description of water clarification and mentioned an additional coagulant belonging to a related species:

> Water from wells which are close to the irrigation canals and ditches of cities is easy to be mixed with turbid water... it should be boiled and layed up for a while before use ... it will become dirty after raining and thus should be clarified with peach or apricot kernels (*Bencao gang mu*, vol.2).

Fifty years later, the scientist Hang Yizhi mentioned, in his *Wuli Xiaozhi* (Small Enzyclopaedia of the Principles of Things, 1643, chapt.2) not only almonds (!) but also read beans and white alum as coagulants (Pan: personal communications in English).

Notes of foreign scholars on the use of plant coagulants for Nile water (16th - early 19th century)

Neither the ancient Egyptians nor Greek and Roman historians reported that turbid Nile water was treated with coagulants. The first known eyewitness account of the clarification of Nile water with a plant material dates back to the end of the 16th century. The Italian physician Prospero Alpino was very interested not only in medicine and natural sciences, but also in meeting Egyptians of all classes and religions during his stay in Cairo from 1581 to 1584. After his return he wrote a book in Latin on the medicine of the Egyptians which he presented in the form of a dialogue between himself and an inquisitive colleague. When discussing water purification, his colleague Wieland already knew that Galenius (2nd century A.D.) had related that the Egyptians filtered turbid water through clay jars. Alpino had seen this method, but he also found another practice to make the water pure and clear:

> As soon as they had brought home water from the river in leather bags made from camel skin, they filled it into large oblong clay vessels with a wide round belly which had a capacity of two amphoras. Once the water had been poured out and the vessel was well filled, they rubbed the opening of the vessel with five sweet almonds which had been crushed slightly, Then they grasped the almonds in their hands and suddenly plunged fist and forearm into the water and moved them vigorously up and down until the water had become more turbid than before. Finally they removed the arm from the vessel and left the almonds in the water and let it clarify. After the water had clarified for three hours, they removed it from the large vessel and poured it into small clay jars where it became even clearer and also cooled down (translated from the French edition, Alpin [name in French]: 65, slightly different text in Baker: 300).

It is doubtful whether the Egyptians at that time really used "almonds", rather than the cheaper apricot kernels, because of confusions between botanic and "trade terminology" in Arabic[5] and the great demand of almonds for sweets and pastry in the houses of the rich. Besides, the kernels of the two species look very similar.

In 1838, Felic d'Arcet, a French chemist, industrialist and writer on scientific subjects, who visited Egypt at the beginning of the 19th century, described once again that turbid Nile water was filtered through porous jars in the north of the country. Coagulation with almonds (!) was common among the poor who could not afford large costly filters. The method was also widely used by the water carriers who brought Nile water to the houses each day. Ground almonds were made into small cakes and sold in all the bazaars. At Sennar and Dongola in the Sudan, different types of beans - broad, kidney or castor oil - were used instead. Since clarification with almonds took four or five hours and still left some visible turbidity, d'Arcet made the first attempts to treat Nile water with alum, which he and his father had already used successfully in France for the coagulation of Seine water (Baker: 300-301).

We owe further information on the clarification of Nile Water by spontaneous sedimentation and traditional coagulation to the German zoologist Alfred Edmund Brehm.[6] Although he was only 18 years old and still a student of architecture in 1847, Baron Müller, a German nobleman, asked him to accompany him on a trip to Egypt and the Sudan to collect exotic birds. Alfred was already well-trained in this field because he had often joined the field work of his father who was a well-known ornithologist (Arndt: 25). The trip included sailing on the Nile from Cairo to Ambikol in the Northern Sudan. Since the entire journey took from September to December, Brehm was on the Nile during the flood season (cf. Jahn 1986: 45, Fig.8) and later described his experiences in his *Reise-Skizzen aus Nord-Ost Afrika* (= travel sketches from Northeast Africa):

> When the river [Nile] has reached its highest level, the water carries so many soil particles that it turns a light brown colour. If it is left to stand quietly for a long time, or if it is mixed thoroughly with fast clarifying alum, bitter almonds (!) or broad beans [= *Vicia faba*] and other such things, the mud particles which are responsible for Egypt's fertility settle at the bottom. The layer which they form comprises one twelfth of the volume of the vessel. Water consumed without clarification causes diarrhoea or a rash which the Arabs simply call "Nile rash". Thus, it is inconceivable that water with such properties is the best drinking water. Yet, travellers who praise the delicious Nile water are right when they say there is no better water in Egypt than that of the Nile (original text in Arndt: 62).

Preconditions for the Development and Transfer of Coagulation Practices

Availability of the necessary plants

The easiest way to benefit from useful foreign plant products is to collect the seeds and to try to grow the plant in one's own country. As far as *Strychnos potatorum* is concerned, demand for seeds could hardly be satisfied in their country of origin and people were obliged to look for substitutes. The seeds which are still sold in Indian markets, e.g. for medicinal purposes, are mainly collected from wild trees in woodlands and close to river banks. Cultivation is still rare. Obviously it is difficult to grow the trees from seeds. Indian foresters have not investigated this thoroughly, but they have observed that strong shoots sometimes grow from the roots of the tree and therefore consider vegetative propagation by root suckers the most promising type of propagation (Gulati: personal communication).[7]

Apricot (*Prunus armeniaca* L.) and peach trees (*Prunus persica* [L.] Batsch) originate in China and could therefore easily be provided for water coagulation there. Almond trees (*Prunus amygdalus* Stock. syn. *P.dulcis* [Mill.] D.A.Webb) originate in Central Asia and were not known in China in the Middle Ages. Almond kernels of "Western origin" (*badan xing ren* = foreign apricot kernels !) were introduced to Chinese folk medicine only a few centuries ago. Now, trees of this species are also planted in Northern China (Leung: 137 ff.).

Almonds were already imported to Pharaonic Egypt from Palestine and Asia Minor. Local cultivation of trees has been rather limited until now (Germer: 59).

Apricots have no ancient Egyptian name. So far only a single apricot stone was found in undated refuse of the sacred animal necropolis at North Saqqara (Germer: 61). Their early introduction from Europe is also doubtful. Although Pliny mentioned that an *Armenian plum*[8] was known in Europe in Roman times, not all investigators are convinced that he was referring to an apricot. Some of them even think the species did not come to Europe until the 16th century (Needham et al., vol. 6: 420,422). Cultivation was probably still rare, or non-existant, in Egypt in the 14th century because the famous traveller Ibn Battuta wrote that apricots from Syria and Anatolia were largely exported to Egypt (Viré: 142). At present, apricots are cultivated mainly in the districts of Faiyum and Qalyub, north of Cairo. An Egyptian school book which I bought in 1960 says nothing about the use of almonds for water purification. Only *nawa l-mishmish* (= apricot stones or kernels !) and alum are mentioned as common clarifiers in rural areas. Middle-aged female informants from the Horticultural Research Institute in Cairo also told me that they had seen only apricot stones in use, with the stony endocarp removed for the purpose. The method was abolished when the Nile water was no longer very turbid following the construction of Assuan High Dam in the seventies. Since then, most of the suspended matter in the Nile water is settled by spontaneous sedimentation in Lake Nasser. Until about 1970, wealthy merchants from Shindi and Wadi Halfa in the Northern Sudan bought almond and apricot stones for water clarification in Egypt. Almond stones were also used sporadically in Tunisian oases. Since European colonists planted almond, apricot and peach trees in suitable climates in Southern Africa and Latin America, water clarification with *Prunus* kernels was sometimes adopted, too. White farmers treated turbid water from the Orange River in Lesotho with almond stones and in the Orange Free State with apricot and peach kernels, but peaches were by far the predominant fruit (Jahn 1988a: 175, Offringa: 1993). In the valleys of northern Potosi in Bolivia where peach trees are grown, the rural people use dark brown extracts of crushed *pepa de durazno* (= peach stones) for water clarification. In the highlands, where these fruit trees do not thrive, peach stones are mixed with crushed beans or beans are used alone (Soliz Rodriguez: 82 ff.). A chemotaxonomy of flocculating plant materials is not only found in the genus *Prunus*. Control of traditionally used materials showed that it also exists in the genus *Maerua*, *Opuntia*, etc., and systematic water treatment studies with seeds from different species of the single-genus family of *Moringaceae* revealed highly efficient coagulants in all seven more common species (Jahn 1988a: Table 1 and 3, 1988b: 44 ff.). Detailed scientific investigation into the possible utilisation of the natural coagulants found in *Prunus* kernels for new water supply programmes has not been carried out yet because the material was found to be too costly, and there was some hesitation on account of the presence of amygdalin in these kernels.

Improvement of coagulation methods

In crude methods of clarification which can still be encountered in Central Africa or Latin America, large pieces of bark, entire roots, bunches of leaves or whole cladodes of a cactus with some incisions are left in turbid water overnight or even for several days. In a next stage of development, the water was stirred to speed

up the process. By using seeds of a suitable size, which are easy to count, a first step was made towards applying the plant materials in "standard doses". This could be repeated by other users. Rural women with particularly good powers of observation later discovered that they were more successful if the amount of coagulant was increased or reduced, depending on the turbidity (Jahn 1977: 127). The preparation of a powder from *Strychnos potatorum* seeds (flattened globules, about 10 x 9 x 6 mm) is difficult and tedious, because they are very hard. The seeds can be rubbed on stone, but in traditional water clarification it is more usual to rub them against the rugged walls of a clay jar. This is usually done after the jar has been filled with the turbid water. The concurrent agitation enhances contact between the suspended particles and the coagulant.

The records do not tell us how apricot kernels were applied in China, but later uses of alum show that the Indian method of rubbing a coagulant against the wall of a water container was also known to the Chinese. In villages of Guangdong Province traditional clarification with alum was carried out until 10-20 years ago in different ways.[9] In the home village of the surgeon Prof. Chen Bingxie (1993) at the Lian River in Shaoguan county a piece of alum was rubbed against the wall of the water bowl and then left in the water to make it completely clear. We know that *Prunus* kernels were rubbed on the mouth of clay jars in Egypt - as we learned from Alpino - and the subsequent mixing of the coagulant paste with the turbid water was not by stirring but by up-and-down movements of the forearm. The same method was still practiced by some of the women in the villages of Lower Egypt in this century, other women added crushed kernels or sometimes crushed endocarp and kernels to the turbid water, as it was also done in the Sudan, Lesotho or Bolivia. Although the flocculating agent is obviously found in the kernel, a mixture with endocarp only means that the dose of clarifier has to be higher.

Translations of Sanscrit scriptures on medicine into Chinese and Arabic

The *Sushruta samhita* and related medical textbooks have aroused the interest both of Chinese Buddhist and Arab Moslem scholars. The Buddhist monk Yijing (I-tsing), who was in India from 671 to 695, translated some medical literature into Chinese. Although he did not mention Sushruta by name, it is very likely that he knew his writings. The quotations from this translation which Jolly provided (1902: 565) do not deal with water purification. Most of the court physicians of the Abbaside caliphs in Baghdad were Nestorian Christians trained in Greek medicine. Nevertheless, translations of Indian medical literature into Arabic were also sponsored (Kremer: 181,454). In the middle of the 9th century, Ali ibn Sahl Rabban at-Tabari referred in the "Indian Books" of his *Firdaus al Hikma* to selected teachings of Sushruta. Like Yiqing, however, he was interested mainly in the sections on the Ayurvedic medical system and examples of Indian pathology, diagnosis and therapy. In his chapter "On the waters" (chapt. 11, Siggel: 1121) he only says vaguely that contaminated water should be purified and kept in clean clay jars, and that the clarification should be done carefully. Neither a method nor a clarifying material is mentioned.

The possible role of Buddhism in the transfer of clarification practices

The teachings of Buddha had probably reached China by the time of the emperor Wu (B.C. 140-87, Franke: 296). From the early centuries A.D., many Chinese pilgrims came to India, and also many Indian Buddhists came to China. Sanscrit schools were opened. The "foreign priests from the West" not only contributed to the dissemination of Buddhism, but were also much respected for their experience in natural sciences and technology as the following example shows. In A.D. 120, Chinese workers engaged in excavation work to turn swamps into an artificial lake at Kunming (Yunnan) detected "black lime" (= naphta or asphalt). According to the *Wudi ji* of the Han Annals, the Indian Buddhist monks were asked about this matter on the order of the emperor. They explained: That is the rest of the destructive processes of sky and earth (Franke: 302). Indian monks may have taught in the valley of the Yangtze River, and Indian artisans may have been involved in the construction or decoration of the sanctuaries there. Since tea is offered to visitors in Buddhist temples, images of Buddhas had to be bathed regularly with scented water, the monasteries opened guest houses for the poor and for paying guests and held great "vegetarian feasts" after religious ceremonies (Ch'en: 171,260,265), ground water could not satisfy all needs. River water also had to be used. Thus, ways of achieving fast clarification during the rainy seasons were most welcome. Buddhism had sanctioned the use of *kataka* seeds for water treatment, but there must have been objections to clarification with glue which is an animal product. Since it was not easy to plant *Strychnos potatorum* trees in China, a substitute was needed. In this respect it was probably significant that the Yangtze basin was famous for its orchards, and the apricot and the peach, which was also used later, are fruits from trees which had been chosen as symbols for months of the Chinese calendar (Eberhard: 23 and 226). Besides, the identification of local efficient coagulants was a valuable adaption which supported the growing trend against the "Indianization of Chinese life" by Buddhism (cf. Ch'en : 3 ff.).

The possible role of Islam in the transfer of clarification practices

With the coming of Islam, beer, which had been the main beverage of the working classes in Egypt, had to be replaced by water because of the prohibition of alcohol. When Muslim pilgrims from India came to the Arab world, and Arabs spent more time in India, ancient Hindu methods of water coagulation may have been noticed and brought to Egypt, leading to the identification of apricot or almond kernels as substitutes. However, the independent detection of the same coagulants in Egypt and China has not been confirmed by records so far.

Sometime between A.D. 618 and 626, four disciples of the prophet Mohammed are supposed to have brought Islam to China (Hirth and Rockhill: 14). In the middle of the 8th century, Arab and Persian traders often called at Canton and other ports in Southern China. A port with a customs' office on the south bank of the Yangtze River at Jiangyin, some 135 km from Shanghai, was established in 1146 during the Song dynasty, but this inland route was probably of relatively little significance in Arab-Persian trade (Reischauer: 143 and 144). Moreover, Egyptians probably came to China much later than other Arabs. Most

traders and the crews of their ships were from Hadramaut. Cargo destined for Egypt had to be transferred to other ships on the Red Sea and then crossed the desert by caravans. A few Chinese merchants visited Egypt in the 12th and 13th century and also saw the Nile. Zhao Rugua, a Chinese inspector of maritime trade in Fujian, compiled in his *Zhufan ji* information on medieval sea trade, foreign countries and people. He describes in detail the day-by-day rise of the Nile until its highest level is reached and how the farmers benefit from it (Hirth and Rockhill: 116), but he says nothing about the muddy water or about water treatment. After Islam had spread more in China in the 13th to the 15th century, assimilation of the Chinese Muslims also increased. It was quite common at that time for Muslims of Arab, Persian or Turkish origin to marry Han-Chinese wives who had been brought up in other religions and, therefore undoubtedly introduced the local methods of water purification to their new homes. With the successful development of Chinese shipbuilding, travel to the Middle East also became easier and the number of Chinese pilgrims to Mecca increased. Part of the fleet of the last great sea expedition led in 1431 - 1433 by Zheng He, a Chinese Muslim from Yunnan, sailed to Djidda. We do not know the number of passengers, but each expedition consisted of several dozen junks carrying a total of about 20,000 people (Gernet: 336 ff.). After making the pilgrimage to Mecca, some Chinese Muslims probably also visited Egypt to engage in trade or to study at the famous Al Azhar University in Cairo. As in later centuries, many foreign students or scholars were probably invited to stay in the homes of their Egyptian teachers or colleagues as members of the family (cf. Hottinger: 38). Wealthy merchants may even have come from China with their servants who had to attend to their needs of clean water both for consumption and ablutions before prayer. Apricots were available in the markets at that time. Egyptian Muslims will have been quite content to learn a faster method of water clarification with a local material from fellow Muslims and particularly from Chinese Muslims, because a famous Hadith (saying) of the Prophet runs: "Seek for learning, though it be as far away as China".

Conclusions

It is certainly not by chance that early accounts of water coagulation come from the valleys of the two longest rivers in Asia and Africa which are known for their high sediment loads because the most impressive results can be seen after treatment of highly turbid waters. Turbidity removal is more difficult if most of the suspended matter consists of coloidally suspended particles. Apart from using alum, ordinary people failed to clarify raw waters of medium or low degrees of turbidity with a traditional coagulant because without optimum doses or proper agitation even the most efficient natural coagulants will not yield satisfactory results (Jahn 1986, chapter 2). Early documentation of water coagulation also shows that such methods were particularly important for the lower classes. Their development depended on the skills of women and male servants. Presumably even the income opportunities of a profession, such as the Egyptian public water sellers, were better if they mastered water coagulation. The wealthy classes had alternatives as regards water supplies. They could afford to dig wells at different sites on their land until they found water with a pleasant taste, and on their

travels they could buy good quality groundwaters. For river water, they built large cisterns in the court yards of their houses (Hottinger: 55) to allow for long-term spontaneous sedimentation, and they had enough space to purify the water by combined sedimentation and filtration methods.

In view of almost 2000 years of history of attempts to clarify turbid waters in China and the dissemination of Buddhism and Islam in that country, it seems very likely that the principles of using a flocculating plant material were adopted from India once people could communicate easily and trusted each other because of their common religion. At a later stage, a successful local substitute from the Yangtze valley was transferred to the riverain Muslim communities along the Nile under similar conditions of mutual understanding and trust. Thus, China was both a "receiver" and a "giver" of this technology.

The documents used in the present study are by no means complete. Thus, scholars investigating ancient travel records in Chinese or Arabic for a particular category of data are recommended to pay additional attention to remarks on traditional water treatments.

Notes

1) *Strychnos potatorum* L. is indigenous to India. Strychnos species which were described in Congo, Burundi, Tanzania, Zambia, Malawi, Zimbabwe, Botswana and Mocambique as *S.stuhlmannii* Gilg and *S.heterodoxa* Gilg were found to be identical with *Strychnos potatorum* L., but in Africa, the seeds were never used for water clarification. In Asia, botanists have found cultivated trees in Northern Ceylon and Burma, but there are no reports on the species from China or other countries of the Far East. The earlier suggested transfer of *Strychnos potatorum* from Africa to India by Arab traders is no longer maintained. (Leeuwenberg 1969: 218ff., 1993: personal communication; Wang, regarding China: personal communication, 1993).
2) Mentioned by Dr. Parameswara Aithal (Südasien Institut, University of Heidelberg, 1980).
3) The most common English name for *kataka* or *Strychnos potatorum* seeds is *clearing nuts*, which is an adequate description of their action, but is not correct from a botanical point of view. The fruits are cherry-like drupes. The translation *soap nuts*, which is also found in studies of philosophic texts (Porter: 43), is a total misunderstanding, since *kataka* seeds were never used for washing purposes and do not contain saponins. In local literature on useful plants, the English name *soap nut* tree refers to *Sapindus trifoliatus* L. (Dastur: 142). Thanks to Indian papers by natural scientists and water engineers, *Strychnos potatorum* seeds became known to the international community under their Hindi name *nirmali* seeds (*nir* = remove, *mala* = dirt or slime).
4) The Chinese name for apricot has been transcribed as *xing*, *hsing* and *hing*. At the end of the last century, Bretschneider (part 2: 293, part 3: 422) pointed out that the term *hing jen* (*jen* also *ren*) = apricot kernels had been incorrectly translated as "almonds" by several European scientists and customs authorities because the kernels of apricots and almonds have almost the same chemical composition and they are both used for the extraction of "almond oil". The mistake was obviously compounded by the fact that the Chinese have sweet- and bitter-tasting apricot kernels, similar to the varieties of sweet and bitter almonds. Furthermore, the word "amande" in French (more seldom "Mandel" in German) is used for almonds, almond kernels in particular and other "Prunus kernels". Thus, the confusion has also entered Chinese dictionaries and caused many translation errors.
5) In the High Middle Ages, the Islamic lands which cultivated apricots distinguished between two categories: *Mishmish lawzi* (= almond-apricot) had sweet edible kernels, while *mishmish kilabi* (= dog-apricot, indicating despising) had bitter kernels. Later, apricots with a sweet kernel were also called *mishlawz* (Viré: 1991). In the vernacular kernels of almonds, apricots or peaches are sometimes also called *lawza* (= "almond", Saghir 1993: personal communication).
6) Cf. previous brief references in Jahn 1977: 121 and 1981: 31.
7) In the last century, *Strychnos potatorum* seeds were even recommended by physicians of the British army in India. However, promising attempts to use them as coagulant aid in modern water works (cf. Bulusu and Sharma 1965, further references in Jahn 1981) have been given up so far because of difficult handling and a lack of experience in the cultivation of the tree. In the 20th century water was also clarified in Indian villages and scientific laboratories with seeds from

other species (Jahn 1981: chapter 3 and 6, 1988a: Table 2), but the author has been never told about the use of *Prunus* kernels in this country.
8) The Greeks called the apricot *milou armeniakou* (=Armenian apple).
9) The history of alum treatment in China will be discussed in another paper.

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