African Plants used for the Improvement of Drinking Water

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During the last thirty years scientists in Europe and USA discovered the benefit of plant products like starch, cellulose or gum as coagulant aids in Water Works Operation (Dutch patent 1948, ÖHMAN 1954, VOGH, WARRINGTON and BLACK 1969) and the use of higher aquatic plants like reeds and bulrushes in the biological treatment of waste water (SCHMIDT and SEIDEL 1968).

In other continents improvement of drinking water by aid of higher plants seems to be a very old experience. When Moses led Israel through the wilderness of Shur, they found after three days of thirst the bitter waters of Marah. His people murmured against him, but "he cried to the Lord and the Lord showed him a tree, which when he had cast into the waters, the waters were made sweet." (Exodus 15 v. 22-25). The type of tree referred to could not be identified (MOLDENKE 1952). In India the use of Nirmali seeds (*Strychnos potatorum* L.) for water clarification was already mentioned in Sanskrit scriptures from 2000. B.C. (COHEN, ROURKE and WOODWAARD 1958). The method is still practised by the natives and the coagulant has been investigated in detail in the Water Research Centre of Nagpur (BULUSU and SHARMA 1965, TRIPATHI, CHAUDHURI and BOKIL 1976). In the 17th Century people in Lithuania made the waters of rivers and brooks potable by adding root pieces of *Acorus calamus* L. (NIELSEN 1976). This knowledge came probably also from Asia. Nomads of Afghanistan threw pieces of calamus root into the drinking water for their horses and the Mongols used to grow the plant close to their watering places (Personal communication to the author). In Peru water is traditionally clarified with the mucilaginous sap of "tuna" leaves (*Opuntia ficus indica* Mill., *O.monocantha*, *O.tuna*, *O.vulgaris*, *O.inerme* etc.) These cactus plants were brought by the Spanish invaders from Mexico but it is not known whether they also introduced the method. In Lima two potent coagulant aids "tunafloc A and B" were recently isolated from *Opuntia ficus indica* (KIRCHMER, ARBOLEDA and CASTRO 1975).

In the Nile valley the use of plants for the improvement of drinking water has probably been known for a long time, although it is difficult to find early documentation. The German Zoologist Alfred Edmund Brehm who was travelling on the Nile in September-December 1847 from Cairo to Ambikol (south of Korti in the Northern Sudan) mentions that the people treated muddy Nile water with bitter almonds and horsebeans (ARNDT 1975), plants which are still in use.

The present paper is based on observations from my field trips in the Sudan: the valleys of the Blue Nile and the River Nile and neighbouring semi-desert areas, Northern Kordofan and Southern Darfur. Some data about the Southern Sudan were obtained from infor-

mants in Khartoum and Darfur. Information on Tchad, Nigeria and Tunisia was collected during short visits during my summer vaccation in 1977 and from informants met in Khartoum.Local names in brackets are terms in Sudanese Arabic unless otherwise indicated. In addition this article deals with some of the results obtained from our laboratory investigation on Sudanese plant floculants. (The research work in the Sudan was sponsored by the National Council for Research).

Raw waters treated with plants

In rural Africa plant materials are added to waters either to settle the mud or to remove unpleasant smells and tastes. On account of heavy summer rains the waters of the Blue Nile, the River Nile and their tributaries can carry up to 8000 mg/l suspended matters for several days. Transient increases are 3-5 times higher (JAHN 1977). Waters with high turbidity are also found during the rainy season in "khours" خور (intermittent streams) and in rain ponds ("fulas" فولة or "rahads" رهد). In some "hafirs" حفير (artificial catchment basins for rainwater) turbidity can be high throughout the year. This type of surface water is treated with plant materials inducing floc formation. In the riverain Sudan the use of plants is at present decreasing in favour of another natural coagulant, a type of clay soil called "rauwāq" رواق (clarifier, JAHN 1976), but in the Western Sudan soil material from termite hills is only an occasional and rather poor competitor with plant flocculants.

Waters in open wells and small water holes have often a bad smell due to pollution with animal wastes. Similar conditions can be found in the waters of permanent shallow wells in the beds of intermittent streams from which water is drawn during the dry season. The ideal type of "gammām" جمام (shallow well in stream bed or close to the shore) is found in intermittent streams with sandy or gravelly soils, as e.g. in Khour Tomat (Blue Nile Province) or Bahr el Arab (Southern Darfur) where every consumer digs a new hole. But the conditions are very unfavourable in intermittent streams with loamy soils as e.g. in the Rahad, tributary of the Blue Nile. Scented plants may act as deodorants or at least suppress repellant smells. Similar conditions as described for the Sudan are present in neighbouring African countries.

Origin of African plant methods

One of the basic concerns of primitive man is to protect himself from the powers of evil: malicious spirits, witches, devils and the evil eye which might bring him disease or death. By covering or mixing his foods and drinks with powerful amulets he thought to prevent their pollution. In rural areas of Kano State (Nigeria) people claim even to-day that a witch will not be able to spoil the water of their jars if they have put roots of *Securidaca longepeduncu-lata* or *Vetiveria* sp. in it. In an oral tradition from the prophet Mohammed, a "hadith" related by Gabir Ben Abdallah and collected by BUKHARI (IBN HAGAR 1959, 1972), the believers are exhorted to cover their drinks at night. In emergencies a small "rod" should be enough to cover milk. Besides the name of Allah is pronounced as a protection from devils. I observed that pious people in Darfur put a stalk of Sorghum-millet over a glass of water as soon as they have taken the first draught in order to prevent pollution by the "shaitān" (devil). According to Moroccan folk belief the rhizoma of *Cyperus rotundus* repells djinns (NAUROY 1954). For protection from evil spirits at the rites of the seventh day celebration, the mother and her new-born child take their bath in the oasis of Kharga (Upper

Egypt) in water to which leaves and branches of *Citrus aurantifolia* have been added (Osman KHAIRAT 1969. These scented plants are believed to possess magic properties; the particular materials chosen are however also useful for water purification as will be shown later. Thus it is quite likely that experiences with such plants have paved the way for subsequent discoveries of more potent water coagulants.

Native technologies for the utilization of plants

a) Treatment of water sources:
Self purification of certain rain ponds or khours due to the presence of aquatic plants has been noticed by the natives of the eastern parts of the Blue Nile Province and may be known also in other parts of the country. In the area mentioned people claim that water is clear in the presence of "dīs" ديس and "sē'da" سعد whereas water of other rain ponds remains turbid. Dīs is not a specific name. It can mean *Typha angustata* Bory and Chaub, *Cyperus papyrus* L., *Cyperus schimperianus* Steud. or *Cyperus* sp. in general. Also "sē'da" سعدة or sē'd can stand both for *Cyperus* sp., *Cyperus schimperianus* Steud. and *Cyperus rotundus* L. People prefer to draw drinking water from places of this type.

Direct purification of small rain ponds with water coagulants is practised e.g. in some villages in Kano State (Nigeria) where the natives throw pieces of wood from *Piliostigma reticulalatum* into the water and draw their supplies some hours later.

b) Water coagulation in rural households:
In rural houses turbid waters are treated by the women by water coagulation in storage vessels. Drinking water is usually clarified in water jars of burnt clay. Water for bathing and washing is treated in barrels and canisters but often not with the same zeal. In primitive methods pieces of bark or root or hand-fuls of leaves are thrown into the storage vessels or branches and roots of certain plants as *Maerua crassifolia, Boscia senegalensis* and *Maerua pseudopetalosa* are turned round for 20 - 30 min. Crushed plant material acts faster. In the Sudan most care is given to water coagulation in the Nile valley, where the most important materials are seeds from cultivated species of *Papilionaceae* or from Moringa trees. The women clean the seeds well before use, grind them thoroughly in a mortar and learn to choose a suitable dose of seed powder for a given turbidity of the raw water (JAHN 1977). Usually the seed powder is added to a small amount of water in a deep plate or calabash and stirred for 10 - 30 min by hand, with a stick or a spoon.The suspension is then poured on the turbid water of the jar. Some women have learnt to prevent that the drinking water acquires a bad smell from putrifying plant material even if it is kept for 24 hrs. They pour the suspension of seed powder (*Faba vulgaris*) through a sieve or put powdered seeds (*Moringa sp.*) in a small bag of clean cloth to which a thread is attached. These bags are then turned round in the turbid jar water. Another advanced technique is the use of pounded seeds of *Hypoestes verticillaris* as a "coagulant aid" in combination with alum from the local markets (one spoon-ful seed powder and a piece of alum as big as a broad bean for the clarification of 20 l turbid Nile water). However average women in the rural Sudan would have difficulties in carrying out water coagulation in this complicated way.

A special method for the clarification of tea water is practised in the area of Radom (Southern Darfur). A piece of bark from *Grewia*

bicolor is boiled with water and then discarded. The extract is described as mucilagenous.

From a comparative point of view it is interesting to note that water coagulants like *Moringa oleifera* seeds or slices of fresh *Abelmoschus esculentus* fruits are also used for the clarification of honey from wild bees (Darfur) and from dates (Northern Province).

c) Water purification outside the houses:
Nomads and semi-nomads or men travelling on donkeys or camels try also to carry out water purification when a suitable plant is available and they have experience in its use. Their plants of choice are *Blepharis persica*, *Boscia senegalensis* and *Maerua crassifolia*. For occasional consumption muddy water is treated in a great gourd half. Leaves from Boscia or Maerua are also put in the opening of the "qirbas" (leathern water bags). As long as the water is stored, extraction of the coagulant goes on. When it is poured out, the leaves act as a mechanical filter.

In "Dar Hamar", the territory of the Hamar tribe in Northern Kordofan, water in some villages is still stored in "Tibaldi trees" تبلدى (Baobab, *Adansonia digitata*) specially hollowed out for this purpose. Tibaldi water is always polluted with soil and organic material and this pollution will increase if the opening to the reservoir is not well blocked. If more than half of the stored supply had been removed the water looks usually rather turbid. It is drawn with a small leather bucket called "delu". Branches of *Boscia senegalensis* or *Maerua crassifolia* are traditionally put into its opening to make sure that the vessel is filled with water. In this way the turbid water gets some initial improvement before it arrives in the houses.

Drinking water for pasturing animals is sometimes also clarified. Plant materials with coagulating property are thrown into the water holes for animals or in small clay-coated basins dug in the ground. Some natives put palm fans from *Phoenix dactylifera* or *Borassus aethiopium* as mechanical filters at the inflow.

Treatment of bad-smelling waters is carried out both outside and inside the houses. Leaves, roots etc. are immersed or people add crushed materials.

Classification of the plants

In the Northern Riverain Sudan the majority of plants used for treatment of turbid waters belongs to the family of *Papilionaceae* (Table 1), which are cultivated there. The most potent water coagulants in this family are *Faba vulgaris* and *Arachis hypogea* followed by *Lathyrus sativus* and *Trigonella foenum-graecum*, however the seeds of the latter may give an unpleasant flavour to tea and other drinks.

In the Blue Nile Province and the Western Sudan the majority of plants for traditional water coagulation belongs to the family of *Capparidaceae* (Table 2, nomenclature according to ELFFERS, GRAHAM and DEWOLF 1964). The most potent are *Boscia senegalensis*, *Maerua pseudopetalosa* and *Maerua crassifolia*. Excess of root or bark from *Boscia senegalensis* gives the water an unpleasant taste. Roots from *Maerua* sp. are clarifying and sweetening. The most appreciated and efficient natural coagulants in the Sudan are the seeds from Moringa trees: *Moringa oleifera* and *Moringa peregrina* (Table 2) called in the Nile valleys in vernacular Arabic: shagara al rauwāq

شجرة الرواق or "clarifier tree" and in the Northern Kordofan: shagara zakī al moya شجرة زاكى المـوية or "tree purifying water". Tribes of the southern parts of the Blue Nile Province, Southern Darfur and Tchad confound the tree with the indigenous *Sesbania tetraptera* Hochst. ex.Bak. and call it "sesaban" سيسبان .

Potent water coagulants are also the crushed stones from *Prunus* sp. (Table 3) which were probably discovered in Egypt and played a role for the treatment of turbid Nile water before the construction of the High Dam. At present spontaneous sedimentation of the mud takes place in the Nasser lake. *Blepharis persica* is widely used among nomads and semi-nomads.

Among the *Monocotyledons* the pounded rhizomes of *Cyperus rotundus* L. ("sē'da" سعدة) are used both for water coagulation and treatment of bad-smelling waters. The other Arabic names of the plant refer to its fragrance: tīb al khadim طيب الخدم = perfume of the servant, or the "poor" (Sudan) and misk al raqīq مسك الرقـيق = musk of the slaves (Egypt). Pounded date-stones from *Phoenix dactylifera* L. are only used in emergencies if no other coagulant is available.

Several plants with weak coagulating effects and agreable smell belong to the family of *Poaceae* (Gramineae) and are mainly used for the improvement of bad-smelling waters: in the Sudan (G., Bl.N.) and Nigeria (Kano State) leaves and stalks of *Cymbopogon nervatus* (Hochst.) Chiov. ("nāl" نال , Hausa: Saure) and *Cymbopogon proximus* (Hochst.) Stapf ("maharīb" محريب or "hamarīb" حمـريب , Hausa: Saure) and in Nigeria (Kano State) and Senegal (Prof.Kerharo) the roots of *Vetiveria zizanoides* (L.) Nash. or *Vetiveria nigritana* (Benth.) Stapf. (Hausa: Jema). Pleasant flavour is also given to the water by pounded almonds and pounded seeds of the local *Hypoestes verticillaris* and the imported *Hypoestes cancellata* Nees. ("mahlab" مـهلب (محلب) which are also important ingredients of Sudanese perfumes and ointments. The traditional use of the leaves of *Citrus aurantifolia* which also scent the water seems to be restricted to Mahas Nubians who settled at the beginning of Islamization in the Central Sudan. Their tribesmen in the North do not have this practice. According to Kaiser (TÄCKHOLM 1969) branches of *Varthemia montana* (Vahl) Boiss., family *Compositae* (nehēda نهيدة , henēda هنيدة or enhēda أنهيدة in Egyptian Arabic) ameliorate water in Sinai. The type of action is not indicated. Finally one might mention the widespread use of rose-, jasmine- and orange-flower waters to flavour drinking or washing water in the Maghrebian countries and Egypt.

Factors in favour of the traditional use of plants for water treatment

Methods for the improvement of water quality in rural areas of Africa which can be carried out with local plants carry very low costs. Several of the plants are also collected to be used as foods and drugs in folk-medicine, thus the people feel confident that they will be wholesome if they are added to water.

a) Plant flocculants used as foods:
All *Papilionaceae* seeds mentioned in Table 1 are foodstuffs for cooking. In Nubia most of them are also ground into flour and added to wheat flour for baking round bread cakes called "gerūb" or "gerūbin kābid"(Mahasi). From *Abrus precatorius* the leaves are sucked as "liquorice". Similar sweeteners are the roots from *Maerua sp.* (Table 2), in the Sudan indicated by the name "irq al shirba" عرق الشربة = root for drinking. People are in the habit of chewing root pieces

of *Maerua pseudopetalosa* when attending their herds and at home and consume great amounts of water in order to enjoy properly their sweet taste. *Moringa oleifera* seeds are added to curries in Tanzania (WATKINS 1960). Leaves of *Corchorus olitorius*, fruits of *Abelmoschus esculentus* and bark of *Grewia bicolor* (Table 3) provide the raw material for very popular mucilagenous vegetable broths ("moulach"), the latter known as kakundshi in rural areas around Radom (S.Darfur). *Hypoestes* seeds are sometimes used as condiment and the Maghrebian national dish "kuskusi" is spiced with rhizomas of *Cyperus rotundus* (NAUROY 1954), which are also chewn by herdsmen in Tropical West Africa (DALZIEL 1937). Refreshing drinks are prepared from the seeds of *Adansonia digitata* (Sudan) and ground almonds ("orgeat" in Tunisia).

b) Drugs in Native Medicine:
In the Sudan water coagulation is believed to protect from diseases. Brehm mentioned already in the middle of the last century that unclarified Nile water is considered to cause diarrhoea and a skin rash called by the Arabs "Nilausschlag" (ARNDT 1975). Similar beliefs existed in Europe: the Dutch physician Dodonaeus (1517-1585) claimed that water from rivulets treated with calamus root is safe with respect to "Plock Feiber" (gastric fever, NIELSEN 1976). As shown in Table 4 several African plant materials with coagulating properties are considered to be effective in the treatment of gastro-intestinal disorders. In case that a potent coagulant, as e.g. *Faba vulgaris* seeds, is believed to lack such properties the natives may try to compensate for this. Some women in Merowi (N.Sudan) prepare a mixture of pounded Faba seeds and "garad" قـرض -powder (pods of the Sunt-tree: *Acacia nilotica* (L.) Willd. ex Del.) for water purification as soon as any member of the household is suffering from diarrhoea or dysentery in order to prevent spread of the disease. In addition there are plant flocculants used as mouth wash or for the treatment of tooth ache and gingivitis: *Boscia senegalensis* as root powder or infusion in Nigeria (Bornu) and Tchad (Bagirmi), *Cyperus rotendus* (rhizoma powder) in the Sudan (No.), *Hypoestes* sp.(seed powder) in the Sudan (Dongola), *Maerua crassifolia* (leaves and bark) in the Sahara (Dr. Burkill, pers. comm.) *Mimosa pigra* (Infusion of leavy stem) in West Africa (IRVINE 1961), *Piliostigma reticulatum* (bark extract) in Congo (IRVINE 1961) and *Securidaca longepedunculata* (chewed root) in East Africa (WATT and BREYER-BRANDWIJK 1962). Skin rashes or wounds are treated with: *Abrus precatorius* (leaves) in Nigeria (IRVINE 1961), *Balanites aegyptiaca* (bark as fumigant) in Tchad (IRVINE 1961), *Boscia senegalensis* as powder or infusion of leaves in West Africa (DALZIEL 1937) and as bark extract in Tchad (Bagirmi), *Maerua crassifolia* (leaves and bark) in the Sahara (Dr. Burkill), *Piliostigma* sp. as root in West Africa (IRVINE 1961) and as bark decoction in Tanzania (HAERDI 1964) and *Tamarix nilotica* (leaves) in the Sudan (Northern Prov.), cf. also BROUN 1906.

Plants used empirically for the treatment of bacterial or fungal infections in man might contain bioactive principles. *Artemisia capillaris* which was known to control infections on the feet of workers in rice-fields was eventually shown to contain one of the most potent fungicides: capillin (WAIN 1969), Table 5 indicates that some of the African plant materials for water coagulation contain also antimicrobial or antifungal compounds. Systematic screening might increase their number. What impact these bioactive compounds could have on water treatment is hard to guess, but should deserve proper investigation (Pers. comm. by Prof. Wain).

c) Laboratory assessment of the improvements of water quality:
Powder of *Moringa oleifera* seeds (2oo mg/l) was able to reduce the residual turbidity of hafir waters (total solids: 6500-8000 mg/l) after one hour by 96 - 98%. The effect of the classic water coagulant aluminium sulfate added in the same concentration was only slightly better. Also the powdered root of *Maerua pseudopetalosa* was a potent coagulant (reduction of turbidity: 92%) but the clarified water obtained soon a brownish discoloration (JAHN and DIRAR 1979). Different types of *Papilionaceae* seeds (*Lens esculenta, Phaseolus roxborghii, Trigonella foenum-aracuum, Cajanus indicus*) and *Caesalpiniaceae* seeds (*Tamarindus indica*) were tested in the Water Research Centre of Nagpur. They were poor "primary coagulants" but they seemed to be promising as "coagulant aids". Used in combination with alum they could save 40 - 54% of the consumption of this coagulant (BULUSU and PATHAK 1974, Technical Digest No. 52, 1976). As primary coagulants the Indian preparations of *Papilionaceae* seeds left even after several hours a residual turbidity of ca. 300 mg/l. Moringa seeds could achieve a final reduction to ca. 40 mg/l.

Thirty minutes after adding 200 mg/l Moringa seed powder there was an initial decrease in the total bacterial count of hafir water from 1 - 1.3 x 10^5/ml to 0.4 - 1.0 x 10^4/ml (= 4-8%). This effect seems to be due to efficient flocculation and sedimentation resulting in removal of bacteria. It was of the same magnitude after treatment with alum (JAHN and DIRAR 1979). Specific effects of water coagulation with Sudanese plant materials on pathogenic bacteria were not yet studied.

Risks from the uncontrolled use of plants for water treatment

a) Bacteriological water quality at long storage:
Plant materials fit for water coagulation contain an active ingredient and besides different types of organic material which may be useful as a substrate for the growth of bacteria. The initial decrease in the total bacterial count after water coagulation with Moringa seed powder was followed by a secondary rise, which went on at a similar speed in undecanted and decanted water. After 1 day and 14 hrs the total bacterial count was 300 times higher as in the onset of the experiment (JAHN and DIRAR 1979). Similar observations were made in India after water treatment with seeds of *Strychnos potatorum* (TRIPATHI, CHAUDHURI and BOKIL 1976). Fortunately the practical consequences of these unfavourable side-effects of plant flocculants are not so serious. In most Sudanese villages fresh supplies of drinking water are brought twice daily: in the morning and before sunset. Therefore most of the water is consumed after about 8 hrs which means within a period in which the secondary increase of the total bacterial count after treatment with Moringa seeds (or plant materials in general) is still in its beginning. Besides there are not yet experimental data on growth fluctuations of pathogenic germs.

b) Toxicity of the added plant materials:
Any chemically and toxicologically unknown material added continuously to drinking water represents a potential danger. Attention has already been drawn to possible health hazards from the increasing number of new synthetic coagulant aids (WHO 1970). Coagulant aids applied by water treatment plants are usually absorbed by the floc and removed with the precipitate. People in rural Africa practising water coagulation do not yet care much for a separation of the clarified water from the floc. In the Sudan such a separation is usual-

ly only carried out in some of the houses of the Nile and Northern Province where the general hygienic standard is high. If the plant material remains at the bottom of the jar until all the water is consumed toxic substances could easily pass into the stored water.

Table 6 shows that some plants used for water purification contain dangerous poisons which have even caused fatal accidents. Acton as well as Long observed that the lathyrus factor is extracted by water and this water may prove toxic (WATT and BREYER-BRANDWIJK 1962). Besides *Lathyrus sativus* is a manganophile plant and Mn has a potentiating effect on lathyrism. According to Indian analysis the seeds can contain 5-50 mg% Mn (II) (BERSIN 1963). In Nubia clay soils are rich in manganese (1000-1700 mg/g RÖSCH and JAHN: to be published). However at present the use of *Papilionaceae* seeds, including lathyrus peas is in regress in the Northern Sudan, as pointed out before.

Supplies of wild plants for water treatment are often collected before the rain season and then stored in the houses. The risks involved by the sweet-tasting roots of *Maerua* sp. concern perhaps more the misuse of the stored plant coagulant than its direct use for water purification. The uncontrolled chewing of these roots is certainly encouraged by the present high prices and temporary scarcity of sugar. There are ecological differences with respect to root size and sucrose content of specimens of *Maerua pseudopetalosa* from Bahr el Ghazal (HENRY and GRINDLEY 1949) and from the Blue Nile Province (JAHN and DIRAR 1979) but laboratory studies have to decide whether there are also differences in the concentration of the toxic principle. As a preliminary action we have sent in april 1976 an urgent circular to all health authorities of the Sudan to prevent the use of these roots for water coagulation and as a sweetener. There could be also health risks from materials containing sapotoxins like the bark of *Balanites aegyptiaca* which is a potent fish poison not only in the Eastern and Western Sudan (c.f. also ARKELL 1926), but also in Tchad, Northern Nigeria, East Africa (VERDCOURT/TRUMP 1972) and Senegal (KERHARO 1972). Finally it is known that the - probably half-crushed - bright red fruits of *Abrus precatorius* which are present in a famous Sudanese incense mixture are causing occasional fatal accidents in children in big towns of the Central Sudan (Pers.comm. by Dr. Abdel Hamid Ibrahim, National Health Laboratories, Khartoum). If leaves of this plant are used for water purification in Equatoria there could be also risks that these highly toxic fruits sometimes by mishap pass into the water. Apart from these few examples several other plants used for the treatment of low-quality drinking water might contain toxic substances which chronically affect the vital organs of digestion and excretion which are already basically under a greater stress in African countries due to the tropical climate and wide-spread mal-nutrition.

In conclusion investigation on traditional methods for the improvement of water with aid of plants seems to open very promising possibilities to obtain better water quality in rural areas of Africa at low cost. From the existing great number of plants the most efficient, fast-growing and safest must be sorted out and scrutinized by modern science in order to be re-introduced with some modifications or if possible after isolation of the active principle to achieve also optimal bacteriological water quality. Besides it is of great importance that the methods are simple enough to fit to the socio-cultural standards of the indigeneous people.

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TABLE 1: WATER COAGULANTS FROM THE LEGUMINALES

Species	Name in Sudanese Arabic	Name in other language	Part of the plant	Geographical distribution of the method
	FAMILY: PAPILIONACEAE			
Faba vulgaris Moench (Before:Faba fona Medik.and Vicia faba L.)	fūl masri فول مصرى	broad been fūl (Egypt. Arabic and Mahasi)	seeds	Sudan: No.,Ni. Egypt
Phaseolus vulgaris L.	fasōlia bēda فصوليا بيضاء	haricot, bean	seeds	Sudan: Kh.,G.
Pisum sativum L.	bisilla بسلّة	garden pea	seeds	Sudan: No.
Lathyrus sativus L.	gelbān جلبان	chickling vetch, GURRU (Mahasi)	seeds	Sudan: No.(Nubia)
Lupinus termis Korsk.	turmus ترمس	lupin	seeds	Sudan: Ni.
Lablab niger Medik.	lubia 'āfin لوبيا عفن		seeds	Sudan: No.,D.
Lens esculenta Moench	'ādis عدس	lentil	seeds	Sudan: No.
Arachis hypogaea L.	fūl sudāni فول سودانى	ground nut KOLJI (Kanuri)	seeds	Sudan: Kh.,G.,D. Bl.N. NIGERIA: Bornu
Trigonella foenum-graecum L.	helba حلبة	fenugreek KĀRIM (Mahasi)	seeds	Sudan: No.,Ni.
Abrus precatorius L.	habbat al arūs حبة العروس	Indian liquorice	leaves	Sudan: E.
	FAMILY: CAESALPINIACEAE			
Piliostigma reticulatum (DC) Hochst.	kharūb خروب	kharūb (Tchad Arabic)	bark, pieces of	Tchad:Bagirmi Nigeria: Kano State
Piliostigma thonningi (Schum.) Milne Redh.		KALGO or KARGO (Hausa)		
	FAMILY: MIMOSACEAE			
Acacia senegal L. (Willd.)	hashāb هشاب	KULKUL (Kanuri)	bark	Nigeria: Bornu
Mimosa pigra L.	shagara al mūt شجرة الموت	DIJOSANJOS (Mahasi)	bark	Sudan: No.(Nubia)

TABLE 2: WATER COAGULANTS FROM THE CAPPARIDALES

Species	Name in Sudanese Arabic	Name in other language	Part of the plant	Geographical distribution of the method
	FAMILY: CAPPARIDACEAE			
Boscia senegalensis (Pers).Lam.ex Poir	shagara al mukhēt or شجرة المخيت shagara al kursān شجرة الكرسان (shagar, resp. shadar) (شجر — شدر)	BULDUM (Hausa) BULTU (Kanuri)	bark, root leaves, branches	Sudan: Bl.N., K., D. Nigeria: Bl.N.
Capparis decidua (Forssk.)Edgew.	tūndub طندب		branches	Sudan: Bl.N.
Capparis spinosa L.	lāsaf لصف	caper tree	fruits	Sudan: K. (Nuba mountains
Maerua crassifolia	sēreh سرح		branches bark, root	Sudan: K., D.
Maerua edulis (Gilg & Bened.) De Wolf			root	Kenya: (Dr. Burkill, Roy. Bot. Gardens, Kew)
Maerua glauca Chiov.			root	Kenya: (Dr. Burkill)
Maerua pseudopetalosa (Gilg & Bened) De Wolf (before: Courbonia virgata)	kordāla or كردالة irq al shirba عرق الشربة	BATULU (Kreish) MAYOOK (Dinka)	root	Sudan: Bl., N., K., Uganda: Verdcourt and Trump, 1972
Maerua subcordata (Gild) De Wolf			root	East Africa: Verdc./Trump 1972
	FAMILY: MORINGACEAE			
Moringa oleifera Lam.	shagara al rauwāq or شجرة الرواق shagara za-kī al moya شجرة زاكى المـوية	horsera-dish tree ZOGALAGANDI (Hausa), ANID (Dinka) NUD (Shilluk)	seeds	Sudan: No., Ni., Kh., G., Bl., N., K., D., B.Gh., U.N.
Moringa peregrina (Forssk.) Fiori	shagara al rauwāq شجرة الرواق		seeds	Sudan: Bl.N.

ABBREVIATIONS FOR THE SUDANESE PROVINCES: No.= Northern, Ni.= Nile, Bl.N. = Blue Nile, Kh.= Khartoum, K.= Kordofan, D.= Darfur, G.= Gezira, E.= Equatoria, B.Gh.= Bahr el Ghazal, U.N.= Upper Nile.

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TABLE 3: WATER COAGULANTS FROM DIFFERENT DICOTYLEDONS

Species	Name in Sudanese Arabic	Name in other language	Part of the plant	Geographical distribution of the method
	FAMILY: POLYGALACEAE			
securidaca longepeduculata Fresen	alāli علالى	SANYA or UWAR MAGUGUNA (Hausa)	root	Nigeria: Kano State
	FAMILY: ELATINEAE			
Bergia suffruticosa (Del.)Fenzl.	rimit رمت		leaves ẋ	Sudan: Bl.N.
	FAMILY: FICOIDACEAE			
Trianthema salsoloides Fenzl.ex.Oliv.	dāle دالى		stalks, leaves	Sudan: G.
	FAMILY: TAMARICACEAE			
Tamarix nilotica (Ehrenb.) Bunge	shagara al tarfa طرفة		branches	Sudan: Bl.N.No.
	FAMILY: CUCURBITACEAE			
Cucurbita sp.	qara' قرعة	gourd	seeds	Sudan: K.
	FAMILY: TILIACEAE			
Corchorus olitorius L.	mulokhīa ملوخية		leaves ẋ	Sudan: No.
Grewia bicolor Juss.	basham al abyad بشم الابيض		bark	Sudan: D.
	FAMILY: BOMBACACEAE			
Adansonia digitata L.	tibaldi تبلدى	baobab tree	seeds "qonqulīz	Sudan: Bl.N.
	FAMILY: MALVACEAE			
Abelmoschus esculentus (L.)	bāmia بامية	okra(ladies fingers)	fruits ẋ stalks ẋ	Sudan: Ni. Tchad: (North)
	FAMILY: ROSACEAE			
Prunus amygdalus (Batsch.)	lūz لوز	bitter almond	stone	Sudan: No.,Ni. Egypt Tunisia:Djerid (Oasis Nefta
Prunus armeniaca L.	mishmish مشمش	apricot	stone	Sudan: No.(Halfa) Egypt
	FAMILY: SALICACEAE			
Salix subserrata	safsāf صفصاف	Nile willow	leaves ẋ	Sudan: Bl.N.
	FAMILY: RUTACEAE			
Citrus aurantifolia(Christm.)Swingle	shagara al limūn شجرة اليمون	lime	leaves ẋ	Sudan: Kh.

ẋ = only fresh material

continued

TABLE 3: continued

Species	Name in Sudanese Arabic	Name in other language	Part of the plant	Geographical distribution of the method
	FAMILY: BALANITACEAE			
Balanites aegyptiaca Del.	shagara al higlīg شجرة الهجليج شجرة اللالوب	CHINGO or BETTO (Kanuri)	bark	Sudan:Kh.,K.,D. Nigeria:Bornu
	FAMILY: ACANTHACEAE			
Blepharis persica (Burm.f.)Kuntze	sīha or baghēl سحا بغيل		whole plant fruits	Sudan: Kh.,Bl. N.,D.
Hypoestes verticillaris (Lf.) Soland. ex Roem.& Schult	mahlab مهلب (محلب)		seeds	Sudan: No., Ni

TABLE 4: NATURAL COAGULANTS WITH EFFECTS ON GASTRO-INTESTINAL DISEASES

Species	Symptoms	Type of preparation	Country or region
Abrus precatorius	constipation colic	infusion of leaves	Ivory Coast, Ghana IRVINE 1961
Acacia senegal	dysentery	crushed bark boiled in cow-milk	Sudan: Rufa'a-Arabs (Bl.N.)
Adansonia digitata	diarrhoea	seeds chewed, soaked in water, added to millet-porridge	Sudan: No.,Ni.cf.also Ahmed abdel HALIM 1939
	intestinal disturbances in children	fruits	Senegal: KERHARO/ ADAM 1964
Balantes aegyptiaca	stomach ache intest.worms	bark	Sudan: BROUN 1906 Senegal: KERHARO 1972
Blepharis persica	stomach disorders	tea from whole plant	Sudan: D.
Capparis decidua	dysentery	fruits	Sudan: BROUN 1906
Cucurbita sp.	intest.worms	powder of dry seeds + curdled milk	Sudan: K.
Cymbopogon proximus	spasm of the stomach colic	powdered dry plant + sugar	Sudan: No.,G.
		plant decoction as tea	Egypt: Biasharin and Ababda Bedouins (TÄCK HOLM/ DRAR 1941)
Cyperus rotundus	indigestion in children	fresh rhizoma	Sudan: BROUN 1906
	stomach disorders	dried rhizomapowder + sugar	Nubia (No.)
	dyspeptic affections,int.worms	rhizoma	Egypt: TÄCKHOLM/DRAR 1950

cont.

TABLE 4: continued

Faba vulgaris	gastric disorders	grilled beans	Morocco:NAUROY 1954
Hypoestes sp.	colic in children	decoction of seeds	Sudan:K.(ANDERSON 1908)
	stomach disorders	seeds +germinating sorghum-millet + sugar	No. (Dongola)
Maerua crassifolia	stomach disorders	infusion of leaves	Westafrica:IRVINE 1961
	gastro-intestinal disorders	tea of pounded seeds,roasted seeds added to Abyssinian coffee ("gebana")	Sudan:K.(Fellata minorities)
		tea of seeds	Nigeria: Kano
	diarrhoea	pounded seeds in curdled milk	Tchad: Bagirmi
Moringa peregrina ban بان in class. and Egypt.Arabic	intestinal disorders	tea of roasted seeds	Egypt:Pers.comm.Prof. TÄCKHOLM
Piliostigma reticulatum	stomach ache diarrhoea,dysent.	bark extract bark-infusion	Nyasaland: IRVINE KENYA: 1961
securidaca longepedunculata	stomach ache	cold or hot tea of roots	Nigeria:Kano State
	obstipation	tea	Sudan:Fellataminorities
	intestinal worms	roots	Guinea,Senegal: IRVINE 1961
Trigonella foenum-graecum	dyspepsia, diarrhoea	hot or cold tea of pounded seeds,seeds in milk or millet porridge	Sudan: No.Ni.,Kh., BROUN 1906
	obstipation	seeds	Morocco:NAUROY 1954
	gastro-intestinal disorders	seeds	Algerian Sahara DOREAU 1961
Varthemia montana	diarrhoea stomach ache	tea of whole plant	Egypt: Sinai Post/ DINSMORE 1933, TÄCKHOLM 1969
Vetiveria sp.	colic, flatulence	rhizoma	Egypt: TÄCKHOLM/DRAR 1941

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Ibn Hagar + Osman Khairat

ابن حجر عثمان خيرت

فاتح الباري بشرح البخاري قلة السبوع

الجزء التاني عشر الفنون الشعبية ١٠ — ١٩٦٩ ١٦ — ٣٠

القاهرة ــ مكتبة الحلبي ١٩٥٩

القاهرة

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TABLE 5: BIOACTIVE COMPOUNDS IN NATURAL COAGULANTS

Species	Name of compound	Action	Reference
Citrus aurantifolia	Isopimpinellin (leaves)	antifungal	BERGMANN, BEIJERSBERGEN et al. 1967, cit.: WAIN 1969
Cyperus rotundus	Cyperene I and II (rhizoma)	antibacterial	RADOMIR et al. 1956
Faba vulgaris	Compound S (ungerminated seeds)	antifungal	WAIN, SPENCER, FAWCEtt 1961
Lablab niger, *Lathyrus sativus*, *Lens esculenta*, *Lupinus termis*	Compound in germinating seeds	antifungal	Ahmed Ibrahim NAGUIB 1969
Moringa oleifera	Pterygospermin and other compounds (root, leaves, seeds) x	antimicrobial	DAS, KURUP et al. 1957, WATT and BREYER-BRANDWIJK 1962
Phaseolus vulgaris	Compound in germinating seeds	antifungal	Ahmed Ibrahim NAGUIB 1969
Prunus amygdalus	Compound in almond shells	antimicrobial	GUPTA, BHATTIA et al. 1971

x = According to George et al. extracts of all organs of the plant are active against *Escherichia coli* and *Staphylococcus aureus* (KERHARO 1969)

TABLE 6: TOXIC PLANTS USED FOR WATER PURIFICATION

Species	Toxic substance	Symptoms in man	Reference
Lathyrus sativus	lathyrus factor in seeds: β-aminopropionitrile	"Lathyrism": muscular weakness in loins and legs (degenerat. changes in CNS)	WATT a. BREYER-BRANDWIJK 1962
Maerua pseudopetalosa (before: Courbonia virgata)	iodide of tetramethyl ammonium hydroxyde (in root, effect Curare-like)	convulsive spasm, Collapse, death	HENRY 1948
Maerua edulis (before: Courbonia glauca)	quarternary ammonium compound (Henry)	stomach pains, dizziness, violent vomiting, shivering death	VERDCOURT and TRUMP 1972
Maerua subcordata (before: Courbonia subcordata)	probably similar substance as in previous *Maerua* sp.	intoxication	VERDCOURT and TRUMP 1972
Securidaca longepedunculata	saponins, methylsalicylate	vomiting, diarrhoea, liver affection	WATT and BREYER-BRANDWIJK 1962 VERDCOURT and TRUMP 1972

Redaktionelle Anmerkung: Summary und Zusammenfassung neu gesetzt, Keywords und Schlagwörter ergänzt. Originalseiten [], Résumé der Autorin am Schluss des Heftes, kleine Teile der reproduzierten Textseiten sind teils aus technischen Gründen geringfügig versetzt.

[197] **Summary** Methods to improve water quality by aid of plants are known in the East since 4000 years. Attempts to keep off evil spirits from drinking water the use of plant amulets might have promoted the discovery of clarifying plants. In the Sudan and neighbouring countries plants are used as natural water coagulants and for the treatment of waters with bad smell and taste. Traditional technologies practised by the settled population and the nomads are described. The majority of empirically discovered plants which aid to settle the mud belongs to the *Leguminales*, mainly to *Papilionaceae* and to the *Capparidales: Capparidaceae* and *Moringaceae*. Several plants inducing desodoration belong to the *Poaceae*. The most potent Sudanese plant material for the clarification of turbid waters are the seeds of *Moringa oleifera* Lam. (horseradish tree or drumstick tree). Results of the laboratory investigation are discussed. Plants preferred for water purification are often also appreciated by the natives in any other context. They may be known as foods and as drugs in folk medicine. Examples are given for the cure of gastro-intestinal disorders, diseases of the cavity of the mouth, wounds and skin rushes. Some of these medical plants contain antimicrobial or antifungal substances. Health risks due to traditional water treatment with plants can arise if high concentrations of organic ballast-substances facilitate bacterial growth in the water or if the natives use poisonous plants e.g. the roots of certain *Maerua* sp. which are taken in several countries. Scientifically revised methods of water clarification with coagulants of plant origin are promising for the improvement of the physicochemical and bacteriological water quality with aid of indigenous raw-materials of low cost.

Keywords improving of drinking water – traditional plant use – plants for water improvement – *Moringa oleifera* Lam. – Sudan

[199] **Zusammenfassung**
(Afrikanische Pflanzen zur Verbesserung von Trinkwasser)
Seit viertausend Jahren kennt man im Orient Methoden zur Verbesserung der Wasserqualität mit Hilfe von Pflanzen. Das Bestreben, böse Geister durch Pflanzenamulette vom Trinkwasser fernzuhalten, mag die Entdeckung von wasserreinigenden Pflanzen gefördert haben. So werden auch im Sudan und in seinen Nachbarländern traditionell Pflanzen als natürliche Wasserkoagulationsmittel und zur Behandlung von Wassern mit schlechtem Geruch oder Geschmack verwendet. Die bei der sesshaften Bevölkerung und den Nomaden gebräuchlichen Verfahren werden beschrieben. Die meisten empirisch gefundenen Pflanzen, welche die Ausfällung von Schlammstoffen beschleunigen, gehören zu den Leguminales (Hülsenfrüchtler, hauptsächlich Papilionaceae sowie zu den Capparidales: Capparidaceae und Moringaceae), mehrere desodorierende Pflanzen gehören zu den Poaceae. Das wirksamste pflanzliche Material zur Klärung trüber Wasser sind die Samen der Moringa oleifera Lam. (Behennuss-Baum). In dem Übersichtsartikel werden diesbezügliche Laborergebnisse diskutiert. Die zur Wasserreinigung bevorzugten Pflanzen werden oft bei den Einheimischen auch auf anderen Gebieten geschätzt und dienen gleichzeitig als Nahrung oder Heilmittel in der Volksmedizin. Beispiele derartiger Heilpflanzen zur Behandlung gastrointestinaler Störungen, von Krankheiten der Mundhöhle, Wunden und Ausschlägen sind angeführt. Einige davon enthalten bakterizide oder fungizide Wirkstoffe. Gefahren der Gesundheitsschädigung durch die Anwendung traditioneller Wasserreinigung mit Pflanzen sind dann gegeben, wenn hohe Konzentrationen an organischen Ballast-Stoffen das Bakterienwachstum im Wasser fördern oder traditionell Pflanzen mit giftigen Wirkungen zur Anwendung kommen wie z. B. die in mehreren Ländern bekannten Wurzeln gewisser Maerua-Arten. Wissenschaftlich revidierte Methoden der Wasseraufbereitung mit Koagulationsmitteln auf Pflanzenbasis versprechen indes gute Erfolge für die Verbesserung der physikochemischen und bakteriologischen Wasserqualität mit billigen einheimischen Rohstoffen.

Schlagwörter Trinkwasserqualität – traditionelle Trinkwasseraufbereitung – traditioneller Pflanzengebrauch zur Trinkwasserverbesserung – *Moringa oleifera* Lam. – Sudan

[198] **French Summary (Résumé)** see p. 158, zur Autorin in diesem Heft S. 6 und 132f.