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TRADITIONAL METHODS OF WATER PURIFICATION IN THE RIVERAIN SUDAN IN RELATION TO GEOGRAPHIC AND SOCIO-ECONOMIC CONDITIONS

With 1 figure, 2 tables and 4 photos

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Zusammenfassung: Traditionelle Methoden der Wasserreinigung im Sudan unter Berücksichtigung geographischer und sozio-ökonomischer Faktoren.

Der Sinkstoffgehalt des Wassers im Blauen und Vereinigten Nil hat Jahresschwankungen von <100–> 50 000 mg/l. Ähnliche Schwankungen wurden in amerikanischen Strömen gemessen. Moderne Kläranlagen gibt es nur in wenigen sudanesischen Städten. Uferfiltration zur Flutzeit des Nils ist nicht durchführbar. Die Landbevölkerung wendet traditionsgemäß koagulationsfördernde Mittel an. Die Ausfällung der Sinkstoffe mit einem empirisch gefundenen Ton (arab. Rauwaq) hat sich von der Gezira Provinz nach Norden und Süden ausgebreitet und verdrängt gegenwärtig die älteren Methoden mit Pflanzenmaterial. Am wirksamsten sind die gestoßenen Samen von Moringa-Bäumen (*M.oleifera* und *peregrina*). Moringa ist nahezu im gesamten Niltal von der äthiopischen bis zur ägyptischen Grenze in Gärten fortschrittlicher Leute anzutreffen. Die Anwendung anderer einheimischer und kultivierter Pflanzen hängt von ihrer geographischen Verteilung ab. Frauen sind mehr an Wasserreinigung interessiert als Männer. Beobachtungen über unterschiedliche Resultate ihrer Methoden während der Flutzeit werden diskutiert. Die Abgaben an die berufsmäßigen Wasserverkäufer verteuern die Wasserversorgung aus dem Nil oder Bewässerungskanälen, doch nur 7–10% der Ausgaben entfallen auf Wasserkoagulationsmittel, soweit sie nicht selbst gesammelt werden. Faktoren, die zur Bevorzugung von Nilwasser beitragen und die Frage ob billiges oder „besseres" Wasser, das gewisse Kosten fordert, gewählt wird, werden näher diskutiert.

The suspended solids in the waters of the Blue Nile, the River Nile and their tributaries show a great annual increase during the flood season. Soon after the onset of the heavy summer rains in the highlands of Ethiopia and the Southern part of the Sudanese Blue Nile Province the water of these rivers becomes increasingly brown and turbid. The months of the flood season are July, August and September. The annual maxima usually occur between the beginning and the end of August. In August the River Nile can carry for several days up to 8000 mg/l in suspended matters compared to less than 100 mg/l during the dry season. Much higher values occur transiently. In 1974 f. i. the amount of suspended solids in the River Nile at Omdurman was 22 300 mg/l on 10/8 and in the Blue Nile at Khartoum North it was 50 800 mg/l on 17/8 (Communication from the Laboratory of the Water Works at Mogren, Khartoum).

Annual fluctuations in suspended solids due to a rain season are not an unique phenomenon for the Nile. Table 1 shows the conditions for some great

Table 1: Fluctuation of suspended solids in great American Rivers
(Water year october 1964 to september 1965)

	Annual minimum		
	Date	mg/l	Average during the same month mg/l
Mississippi River at St. Louis	29/12	140	262
Arkansas River near Kinsley	4/10	9	22
Rio Chama above Abiquiu Reservoir	22–23 26–28/10	40	81
Rio Grande at San Acacia	29/11	19	103

	Annual maximum		
	Date	mg/l	Average during the same month mg/l
Mississippi River at St. Louis	9/6	3040	1299
Arkansas River near Kinsley	14/7	15000	1242
Rio Chama above Abiquiu Reservoir	2/8	23000	2748
Rio Grande at San Acacia	1/8	60200	11698

American rivers (Geological Survey, Water Supply Paper, Parts 7 and 8, 1970). Tremendous increases in suspended matter observed only on a single day are probably due to sudden storm rains. The different factors responsible for river pollution due to sudden thunder storms in summer after a longer dry period were recently discussed by GARLAND (1976).

Another cause for sudden overload of rivers or rivulets with suspended matters can be the eruption of a volcano. From march 1963 to december 1964 the volcano Irazu close to San José, the capital of Costa Rica, entered a new phase of strombolic activity. Before the catastrophe slow sand filter systems could cope with the annual increase in erosion products in the rivers during the rain season. After the repetitive eruptions however mobile emergency units for water treatment had to be established (BRYLKA 1967).

The traditional methods of water purification practized during the flood season of the Nile in rural areas of the riverain Sudan are a result of adaptation to the existing geographical and geological conditions.

Difficulties in the application of shore filtration

If a river has got banks of sandy and gravelly soils water purification can be performed by shore filtration. River water infiltrating the shores at a low speed of 1–2 m/day is collected from shallow wells dug at a suitable distance which allows for a long duration of flow. Optimal conditions are obtained if this duration has a length of 50–100 days (personal communication by Prof. HÄSSELBARTH, Institut für Wasser-Boden- und Lufthygiene, Berlin). The method of shore filtration seems to be very old and known all over the world. Until recently drinking water from the Rhine, one of Central Europe's most important rivers was obtained by shore filtration (Umweltprobleme des Rheins, Paragraph 203, p. 89).

For the waters of the Nile shore filtration can not be utilized during the flood season because the rising river covers all sandy islands as well as the sandy and gravelly formations along the shores. Brickmakers working close to the village Qutrandj on the eastern side of the Blue Nile at the border between Khartoum and Gezira Province are said to use shore filtration from the end of September to the end of October. They can not start until the water level has fallen again exposing a sandy stripe of the river bank. During this time of the year the amount of suspended solids in the Blue Nile at Khartoum amounts only to approximately 200 mg/l (cf. graph in Beam 1906).

In the valley of the Gash River, an intermittent stream in Kassala Province some shallow wells are found at a distance of less than 50 m from the river. During the flood season, when the Gash carries a silt load of 8–16 000 mg/l the water in these wells has a very low turbidity. There are however not yet any experimental data concerning shore filtration in the Gash basin (EL TAYEB M. SAEED 1972 and personal communications by the author).

The most important traditional methods of water purification in the riverain Sudan are the use of natural coagulants added in suspension or as an extract to the turbid water of the water jars in order to achieve floc formation. Every household is able to improve the quality of its water supply by this means (JAHN 1976).

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) made an interesting remark about this matter. He mentions that muddy Nile water is clarified with alum, bitter almonds or horsebeans (BREHM p. 62).

The following discussions are based on observations from my fieldtrips in 1973–1976.

Water purification with "Rauwaq"

The arabic word "Rauwaq" means clarifier. It is not a name for a specific substance but a general term for any type of material empirically found to coagu-

Map of the Sudan

late turbid water. People in the riverain Sudan use the term "Rauwaq" however mainly for clay soil which has got these properties.

Clays from river banks and other sites are also used in the Western World for natural "decontamination" of water, mainly to remove radioactive materials (Lacy 1954, Orlova, Gneuševa, Smirennaja and Žogova 1966, Wanderer 1968).

a) Legends about the origin of the method

In the past men in rural communities all over the world considered discoveries which significantly changed their conditions of life to be a gift from their gods or a divine blessing bestowed on their cultural heros. Athene, the goddess of wisdom of the ancient Greeks taught mankind how to plough and how to make pottery. People from Tibet relate how their brave prince Atschu did not hesitate to travel nine thousand Li, to cross ninety-nine mountains and ninety-nine huge rivers to fetch the seed of the Tjingko barley for his suffering fellowmen from Jihwuta, the god of the mountains (Chinas Völker p. 19). To dino (father of the baobab) the cultural hero of the Fali from Northern Cameroun discovered a store of water in the hollow trunk of a baobab tree *(Adansonia digitata)* and watered with it a single grain of red millet, teaching his people how to survive in the days of draught and famine (Lebeuf p. 371).

In the Sudan water purification is also considered to be a divine gift. There may be several legends in other parts of the Nile valley, I know so far only about such tales from a small village in the Gezira Province.

In Wad el Said, on the eastern bank of the Blue Nile close to the present sugar factory of Guned old pious people relate that a Sharif (descendant from the family of the Prophet), the Sheikh Ibrahim Wad

el Hamim had taught them how to clarify the Nile water during the flood season. Ibrahim was born in Ganneb, a village on the western side of the river and belonged to the Rikabiyya tribe having its roots in Yemen (YUSUF FADL HASAN p. 172). He died about 30 years ago, but his khalwa (Koran school) in the shade of an Arak tree *(Salvadora persica)* is still existing.

Ibrahim Wad el Hamim was worried about the darkbrown muddy water of the Nile during the flood season and prayed to Allah to let him find a way to make this water again clean and pure, fit for the ritual ablutions and for drinking. One day his 'okaz, the traditional stick of the religious sheikhs, bent to the ground on the Nile shore in front of his house. He dug some soil on this spot and mixed it with the turbid Nile water in the jar. After a short while it became like curdled milk. The solids settled down and the supernatant water was pure and transparent (Fatima Hassan, Shaiqiya tribe, 65–70 years).

Others relate that the Sharif already knew about water purification with Rauwaq before he arrived to Wad el Said. There he taught the boys in his Koran school how to obtain clean water and they brought in turn the message to their families. Due to the "baraka", the divine blessedness of this pious sheikh the most efficient type of Rauwaq was found in front of his house. Until now the Rauwaq from Wad el Said is known as "Rauwaq of the Sharif" (Soleiman Mohammed Ahmed, Ja'aliyin tribe, 45–50 years).

Less pious people in the village maintain that Rauwaq was known in the Gezira Province since times immemorial and that its discovery can not be related to any religious sheikh (Ahmed Mohammed Hussayn, Maghrebian, 55–60 years).

b) Rauwaq in the Gezira Province

It is not sure wheter the first discoveries of Rauwaq were made in this particular village, but there is no doubt that its soil flocculant is present at different sites although in varying quality. People differentiate these types according to their relation to certain houses. They know about "Rauwaq of the Sharif", "Rauwaq of Derwish" (a neighbour of the Sheikh), "Rauwaq of the Maghrebians" (named after a small Maghrebian community which came to their village from Upper Egypt), "Rauwaq of the khour" and others. The last type has only been known for a few years. It is dug from the dry bed of a small rain pond after the rain season (about 1 km south from the village and 500 m east of the Nile). Some women claimed that this new Rauwaq acted faster. This observation could be confirmed by X-ray analysis carried out in the Institute of Geosciences in Hannover (W.-Germany). The Rauwaq from the "khour" contained a higher percentage of bentonite than a sample of Rauwaq taken from the shore (JAHN and RÖSCH, to be published). Betonite clay has a high swelling and water uptake capacity of its elementary crystals and can act as an ion exchanger. It has been used in the filtration plant of Lake Michigan after initial coagulation with liquid alum (LOUIS 1956). Bentonite was also shown to be a "coagulant aid" in laboratory experiments about the treatment of wool scouring wastes (FONG and LUNDGREN 1955) and waste water from a paper mill (BRECHT, BÖRNER and DALPKE 1974), but it was no "coagulant". Thus it is not surprising that bentonite alone has a rather poor effect on turbid Nile water. There must be other mineral components in the Rauwaq acting as precursors in the coagulation process. We are still engaged to study this question in detail.

Until 15 years ago Rauwaq from Wad el Said and other neighbouring villages was loaded on donkeys and brought to Rufa'a. Early in the morning the boys were shouting in the streets "Rauwaq, Rauwaq ..." selling a bowl with about one Rotl of their valuable soil for half-a-piaster. From Rufa'a the trade extended to Wad Medani and villages close to Khartoum. Now Wad Medani and Rufa'a are supplied with clean water, while many villages on the western bank of the Blue Nile have deep wells instead of the former water supply from irrigation canals. The agricultural schemes of the Gezira Board have contributed much to these improvements. Development has been slower on the eastern bank of the Blue Nile where those schemes were only introduced quite recently. In small towns like Wad Drawa or Abu Haraz, now seats of the local government, the majority of the people are still drawing their water from the Nile.

c) Discovery of Rauwaq in other parts of the Nile valley

Wealthy merchants from Karima, a town on the River Nile in the Northern Province used to bring some Gezira-Rauwaq to their families when they travelled to Khartoum or Wad Medani to sell their dates and to buy other gods in exchange. Water clarification with Rauwaq was considered to be a luxury until a new site was found in their own region. It happened only 10–15 years ago that one day a poor woman went during the flood season of the Nile to fetch water. She took it from the shore at Uqda, a village north of Karima close to the landing place of the ferryboat between Karima and Nuri. Her container was dripping and she tried to mend it with some soil. Her house was far from the shore. When she finally arrived and took the canister from her head she saw to her surprise that the water looked cleaner than she had ever seen it before during that part of the year. She tried to recollect what had happened to her and understood that the soil she had picked up might have caused the change. Nobody can remember the name of this woman, but the Rauwaq from Uqda became soon famous in the area and is

now carried as far as Nuri and El Qurēr on the opposite bank of the river, replacing there increasingly the former habit to drink the turbid water without treatment or to carry out purification with plant coagulants (Photo 1).

Rauwaq is also known in other rural areas along the River Nile from Shindi up to Dongola and Abri. Its appearance is different with respect to colour and consistency and the effect on turbid water is not the same. Two varieties from the Mahas territory have gained particular reputation: clay from the island Badin opposite Kerma el Nuzul and clay from the Khour of Abu Sara. This Khour is said to continue to Abu Hamed. People of Sukkot praise the Rauwaq from Akasha. Neither the Nubian language of the Danagla nor the dialects of the people in Mahas and Sukkot have any name for a clarifying clay-soil. The method seems to be of recent date. Most informants claimed that it was introduced only 3–15 years ago, but since this time water purification with Rauwaq is predominating.

Villages or towns lacking sites of Rauwaq in their vicinity take their supplies from other places. The Rauwaq from Uqda is brought by Nile steamers to Dongola and from there distributed to rural communities. In the riveraine quarters of Berber Nile water is either purfied with clay soil from Abu Haraz on the western bank of the river or with a good variety of Rauwaq from Abu Hamed.

In rural areas along the Blue Nile between Sennar and Roseires Rauwaq is now also replacing traditional purification methods with plants, but in most villages people recollect that it was not discovered more than 10–20 years ago. The Rauwaq from sites close to Maerno and Abu Hugar on the Western bank of the Blue Nile has a yellow colour and is called "tīn sufra" (yellow clay) or "tīn umm dōf" (clay resembling meat with a yellowish fat-layer). In Roseires where the Rauwaq is rather soft and greyish people call it also "turāb al terwīq" (clarifying earth). Tribes living on the western bank of the Blue Nile south of Damazin, like the Hamedj, Berta, Gabalauwiin and the Funj do not know any coagulating clay. For water purification they use plant material.

Other types of soil used as natural coagulants

Apart from Rauwaq there are some other types of soil used for water purification which we have not yet analysed. In the savanna woodlands close to Umm Dubban a brown dusty soil called "barbēs" and recognized by its salty taste is collected but its effect is rather poor. In Berber turbid water is sometimes treated with the socalled "hagar al abyad" (white stone) brought from the semi-desert north east of the town. In addition there are two varieties of natural coagulants consisting of rock stone from Gebel Kassingar north of Karima and from a site at El Karafāb close to Korti in the southern part of Merowi district. They are called "gīr al rauwāq" (clarifying lime).

In the mountain region between Matmata and Medenine in Southern Tunisia people clarify rain water polluted with dust and soil in the collecting tank before entering the cistern with soil containing "gīr" (Communication from the Centre for Rural Engineering in Tunis).

Water purification with plants

In rural areas of several African countries fresh or dry pounded plant material is known to coagulate turbid water. Some of the plants used for this purpose in Northern Nigeria or East Africa are identical or closely related to corresponding Sudanese plants (JAHN 1976 and 1977). In India the seeds of the nirmali tree *(Strychnos potatorum Linn.)* were used for centuries (Technical Digest 1976) and other plants probably also traditional by origin are now recommended as natural coagulant aids to the villages (BULUSU and PATHAK 1974). In rural Mexico and Peru people clarify the muddy water with the mucilage from cactus leaves of *Opuntia tuna*, *Opuntia ficus indica* and related species (KIRCHMER, ARBOLEDA and CASTRO 1975). The natural polymers responsible for the water coagulating effect of plants differ in their chemical nature, but are mainly polysaccharides and proteins.

In the Sudanese Nile valley the choice of plant flocculants depends on their efficiency and their geographical distribution.

a) Moringa trees

There are only two species which have a vernacular name in Arabic indicating their suitability as a water coagulant: the two trees *Moringa oleifera Lam.* and *Moringa peregrina (Forsk.) Fiori* belonging to the family of *Moringaceae*. They are called "shagara al rauwāq": clarifying tree (JAHN 1976) or "rawag": clarifier (HAMZA MOHAMMED EL AMIN 1973). According to ANDREWS (vol. 1 p. 54) *Moringa oleifera* was introduced from India. It seems to be correct that this tree can not be called indigenous to the Nile valley, but it is not yet sure wheather it was introduced from India or from the Western Sudan. In the area of Kafiya Kingi in southern Darfur it occurs as an indigenous tree (personal communication by Dr. Babiker Fadl Allah, Dept. of Botany, University of Khartoum). It is quite likely that some government officials planted *Moringa oleifera* in the public gardens of towns like Wad Medani, Rufa'a, Shindi, Merowi, Dongola and Sennar. Elder inhabitants of Wad Medani and Sennar still remember that there were many trees of this type in those gardens and in the alley along the Nile, but life has changed in these towns. They are now supplied with clean water all the year round. In the public water works alum has replaced the natural coagulants. Although quite at-

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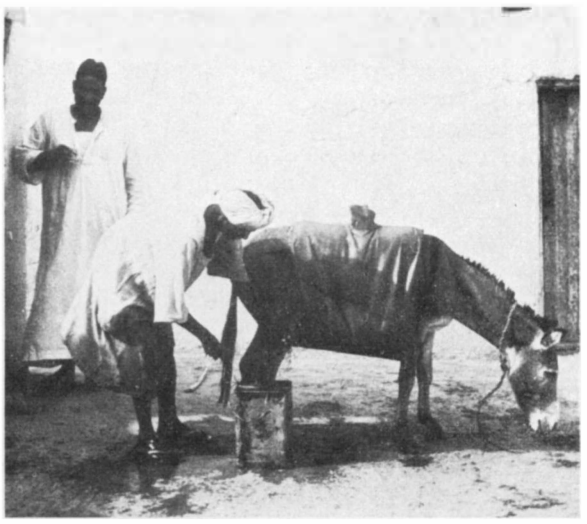

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Photo 1: Rauwaq digging at the Nile shore of Uqda (Northern Province). In the background desert rock formations belonging to the Gebel Kassingar area

Photo 2: A flowering Moringa tree between native grass houses in Roseires. Certain types of bottle shaped cucumber "buchsa" are grown on the roofs of these houses.

Photo 3: Women drawing water from an irrigation canal of Nuri. Their canisters have a capacity of about 20 l. The woman in the black garment (tōb) brought already a small container with Rauwaq (round with stripes) to start water purification on her way home.

Photo 4: A public water seller bringing Nile water to a native house in Merowi. The amount of water is measured in "canisters" (safiha) with a capacity of about 20 l.

tractive in shape the "shagara al shabb" (alum tree) as a gardener in Sennar pathetically called it – is no longer needed. It was cut down or left to die and has now disappeared from all public places.

The situation is quite different in rural areas south of Sennar where the tree is still watered and cherished in private gardens. Again one gets the impression of a migration of tradition from the higher developed central parts of the country. Moringa trees are mainly found in gardens of merchants, omdas (former mayor or chief of a village), religious sheikhs and other people playing a leading role in the social life of the community.

Fellata minorities in Maerno and Gelghani on the western bank of the Blue Nile between Sennar and Damazin are also well experienced in the use of crushed Moringa seeds on turbid water. In these villages *Moringa oleifera* is called by the Fellata and non-Fellata population by its Hausa name "Zogalagandi". A Fellata family in Maerno with ancestors from Northern Cameroun described how they prepare " moulach" a type of thick vegetable soup from young Moringa leaves. This seems to be a typical habit in West Africa. It is reported for the Hausa in Nigeria (DALZIEL p. 23), the Kanuri in Bornu (personal communication from Sheikh Sharif Ibrahim Salih, Maiduguri) and different tribes in Senegal (KERHARO and ADAM p. 315). Moringa leaves are also known as vegetable in Ethiopia (personal communication from Prof. Wolfgang Kuls, Dept. of Geography, Bonn) and seeds are added to curries in Tanganjika (WATKINS 1960), but in none of these countries *Moringa oleifera* or *Moringa peregrina* are used as plant flocculants according to my present knowledge.

In the Southern part of the Blue Nile Province Moringa tress can be found in several villages of the Berta and Gabelauwiin tribe. It is quite likely that the socalled "gelāba", merchants from the Gezira or the Northern Province who opened the trade routes as far as to the mountain regions of Queizan and Kurmuk in the south and to El Qerabin, Mazum and Gebel Dali in the west might have planted the first tress. When people realised that the seeds were also useful for the clarification of the muddy water of their khours and hafirs (artificial lakelike catchment basins for rain water) they introduced the tree to their own villages and small gardens.

In a similar manner Moringa trees seem to have spread from Dongola to private plantations in neighbouring villages like Ertidi and Akja. On their migration to the north they reached towns like Burgēg, Kerma and Abri. Until now one may find a newly planted tree. In december 1976 I saw in the date palm oasis of Hambikol, which is surrounded by the stony Geror*) a tiny Moringa tree in front of the house of a midwife. Two years ago her husband had brought Moringa seeds from Kerma. They are looking forward to collect the first fruits because their water is always of poor quality. The Khour of Hambikol becomes a muddy stream during the flood season of the Nile. For the rest of the year the only source for drinking water consists in pools of bad smelling, stagnating water in the bed of the wadi.

Moringa peregrina (Forsk.) Fiori which is considered to be an indigenous tree in the Red Sea Hills in the Eastern Sudan and occurs sporadically in gardens in Roseires (Photo 2).

b) Geographical distribution of other plants used for water coagulation

There are more than twenty indigenous and cultivated plants used during the flood season of the Nile for improvement of water quality (JAHN 1976, table 3), however they do not all enjoy the same popularity. Apart from Moringa seeds the most important natural coagulant in the southern regions of the Blue Nile is the root or bark of *Boscia senegalensis (Pers.) Lam. ex Poir*, belonging to the family of *Capparidaceae*. In this part of the country the tree is called in Sudanese Arabic "shagara al mukhēt" and by the Fellata "Buldum". *Boscia senegalensis* is also well-known for water purification in the Western Sudan and in Northern Nigeria. Some people in the Blue Nile Province use besides pounded seeds of *Arachis hypogea L.* or *Adansonia digitata L.*, bark of *Balanites aegyptiaca Del.*, branches of *Caparis decidua (Forsk.) Edgew.* or *Tamarix nilotica (Ehrenb.) Bunge* and leaves of *Salix subserrata Willd.* or *Bergia suffruticosa (Del.) Fenzl.*

In the Gezira Province the plant of choice was "ful sudāni" (ground nut, *Arachis hypogea L.)* belonging to the family of *Papilionaceae*, but Rauwaq has now almost abolished its use.

In the northern Province the prefered water clarifiers are cultivated species from the family of *Papilionaceae*, mainly "fūl masri" (horsebeans, *Faba fona Medic.)* and "helba" (fenugreek, *Trigonella foenum graecum L.)* which are grown in this part of the country. Water coagulation is performed with pounded seeds. In addition people have also used pounded seeds from peas, and lentils, *Lablab niger Medic.* or *Lupinus termis Korsk.*, date stones, the rhizoma of the sledge *Cyperus rotundus L.* and branches of *Tamarix nilotica*, but at present Rauwaq is the most commonly used.

Some of the plants known for clarification of turbid water are also used in folk medicine mainly in the treatment of gastro-intestinal disturbances (JAHN 1976 and 1977).

Miscellaneous methods for water purification

Apart from soil and plant coagulants turbid water is sometimes clarified by pouring a thin layer of "rōb"

*) In Mahasi "Geror" means a region which is crossed with difficulty, but left at ease.

(curd) or dough from the traditional flat millet bread (kisra) on the surface of the water. Floc formation can also be induced by any type of plant ash. In the riverain Sudan these methods are rare, they are more popular among nomads and semi-nomads.

Social aspects of traditional water purification

Men in rural communities usually appreciate finding appetizing drinking water in their homes and clean water for a bath. They are proud if they can wear spotless white galabiyas and turbans or neat white shirts and they do not like to see any change in their habits during the flood season. Especially among Moslems there is a great concern about personal cleanness. Regular ablutions are a basic demand of Islam. In the houses men depend on the efforts of the women. If they have to work far from their homes they are less particular about water quality and circmstances may also be very difficult. Cultivators in the fields or plantations, fishermen on the river or men working on Nile steamers and ferryboats drink the muddy water as it is and may also enter the river or the irrigation canal to take a bath. Even in offices of the local government or in some schools little attention is paid to water purification in the public water jars although there are servants available who could be instructed to do the job. In local medical centres not yet supplied with filters one can usually find purified jar water according to traditional methods. In public coffee shops a great effort is made to provide the customers with lime juice which is not discoloured by the ugly brown raw water. Sometimes the owner treats the water with small amounts of alum to ensure a fast reaction and usually he avoids overdoses. In houses alum is mainly used for washing water because excess is known to cause gastrointestinal troubles.

In rural houses water purification depends on the concern and the individual skill of the women. In August 1974 I tried to get some idea about the relationship between the social status of the women and their ability to cope with the hardships of the flood season. Accompanied by Mrs. Safiya Sadeq, one of the leading women in the local government of Merowi district, I went to families with low, medium and high income. Low income refers to a monthly salary of less than 20 L.S. and medium income to less than 60 L.S. Merchants in rural areas may earn an average of 5–6 L.S./day. If they have additional functions or property their income is much higher. Government officials with special experience and many years of service may earn 70–90 L.S. and more.

We asked the women to show us water from their water jar in a transparent tea glass and made sure that water treatment was carried out 6–8 hrs before. The social status of the families under investigation was: low income: 8, medium income: 9, high income: 7.

Among 24 women (13 from the town Merowi – Nile water –, 11 from the village Nuri – water from irrigation canals –) 75% used Rauwaq and only 25% horsebeans (5 women from Merowi, 1 from Nuri, only one family belonged to the low income group). The choise of the coagulant seems to depend on:

Cost: Rauwaq is cheaper, the women may even dig it themselves (Photo 3).

Quality of purified water: Taste and smell of the water do not change after Rauwaq even if it is kept more than 24 hrs and no matter whether the concentration was optimal (water only slightly turbid or transparent) or too high (still turbid and coloured). An excess of horsebeans causes an offensive smell 6–7 hrs after treatment.

Neither good nor poor results of water purification showed any relationship to the age of the women (25–70 years, 40%: 30–40 years).

Women from the low and medium income groups obtained far better results of improvement in water quality than those from the high income group. None of the water samples 6–8 hrs after treatment was still "brown, turbid" like raw water. Among 12 women who had "slightly turbid" or "transparent" water in their jars only one belonged to the high income group. A minimum of furnishing in the houses seems to leave more time for basic household duties. Although the "diwān" (men's quarter) of wealthier families may be very attractive and modernized, most men try to economize on expenses for general house keeping. The women in the high income group have to work as hard as before and there is an additional burden due to a greater number of permanent guests and occasional visitors in their houses. Thus some of them leave the routine treatment of water to servants or young unexperienced girls from the family. Among 7 women of this group 3 had "white turbid" and 3 others even "yellow turbid" water in their jars.

The individual results of water purification undergo of course fluctuations from day to day and the above communicated results only give a rough idea, a kind of "snapshot" for a certain day. One should not forget that the public water works in Khartoum adjust the amount of alum added to the raw water during the flood season on the basis of a water analysis carried out every second or third day. The success of a woman in a rural area is mainly due to a good power of observation, clean handling of the jar and the coagulant and personal devotion to a tough and tedious duty.

Economic aspects of Nile water consumption during the flood season

Unless the people draw the water themselves from the Nile or the irrigation canals the transport fees to the public water sellers (Photo 4) are very high. During the flood season the access to the Nile is very dangerous at many sites in this part of the Northern

Province on account of heavy erosion of the river bank and strong currents. Girls and women do not dare to fetch water as usual. Table 2 gives a comparison of the expenses for a monthly minimum consumption of water for an average family with 4 children.

With a fee of 2–3 Piaster for an amount of about 20 l water – depending on the distance of the houses from the Nile – the inhabitants of Merowi have to pay more for the minimum demand of water needed by their bodies as daily water intake than citizens of Khartoum must pay for 20 m³ water per month. The additional expenses for a natural coagulant sold in the market or brought from a far off site comprise 7–10% of the fees for the raw water.

In areas of the Western Sudan such as the Nuhud district where water is scarse, many families are prepared to spend in summer more than half of their monthly income for water in order to survive!

In view of the great difficulties of obtaining sufficient amounts of purified river water for domestic use during the flood season of the Nile one may ask why the people do not make efforts to dig more wells. In many villages of the riverain Sudan both Nile water and well water are available, but very often Nile water is more appreciated. There are various reasons for this. For the natives of the central and northern Sudan the Nile is no ordinary river with sweet water, it is still a holy stream. Its waters are not only providing the soil with the blessing of

Table 2: Expenses for a monthly minimum consumption of purified Nile water during the flood season

A: *Khartoum standard: 20 m³/month*
Minimum consumption for an *average family* with 4 children in a house supplied with tap water but without syphon in the WC.

Town	Type of expenses	Price per month L. S.	Price per "safiha" (= 20 l) Piaster	Price for 1 kg natural coagulant Piaster	Minimum amount required g/1
Khartoum	Fee to public water works: 0.050 L. S./m³	1.00	0.1		
Sennar	Fee to public water works: 0.065 L S./m³	1.30	0.1 (3)		
Dongola	Fee to public water works 0.065 L. S./m³	1.30	0.1 (3)		
Merowi	a) raw water fee to public water seller	20.0–30.0	2–3		
	b) purified water:				
	– Rauwaq	21.5–32.0	2.2–3.2	5	1.5–2
	– Faba fona	21.5–33.0	2.2–3.3	15	0.5–1

B: *Minimum water demand for a Sudanese citizen:* 5 gallons/day (Yusif Soleiman p. 1)
Water demand for the *average family* (6 persons): *4.1 m³/month*

Merowi	a) raw water	4.10–6.15
	b) purified water	
	– Rauwaq	4.41–6.56
	– Faba fona	4.41–6.77

C: *Minimum water demand in drinks and food in the Sudan:* 6 l per person and day (note from a course for Public Health Inspectors, Khartoum 1967)
Water demand for the *average family* (6 persons): *1.1 m³/month*

Merowi	a) raw water	1.10–1.65
	b) purified water	
	– Rauwaq	1.18–1.76
	– Faba fona	1.18–1.81

fertility they also help to fill the womb of the women with offspring and give abundant milk to the mothers' breasts. Ritual ablutions with Nile water in quest for magic strength and sacrifices to the beneficient spirits, the beautiful Nile maiden (banāt al hūr) or the "angels of the river" (malaīkat al bahr) as they are called in the north, have not yet died out (JAHN 1975, CROWFOOT 1919). A bowl with Nile water kept for 40 days under the angarēb (bed) of a young mother is believed to protect her and the baby from the powers of death, envy and disease.

The fear of well water is not only a supersticious fear but based in many cases on empirical facts. People with a predisposition for stone diseases usually avoid to drink water which is hard and has got a bitter or salty taste. The tropical climate affects the fluid balance. According to estimations of SMITH (1956, table 3) a man of 70 kg weight has in a temperate climate a daily water intake of 2800 ml in food and drinks. His output in urine amounts to 1500 ml or 54%. A man of this type will have in Khartoum during June (the hotest month of the year) a daily water intake of 6600 ml, but an urine output of only 700 ml or 11% because most of the water is lost as sweat. This small volume of urine in combination with large amounts of calcium carbonate in the drinking water may easily facilitate the development of nephrolithiasis.

In addition people know that the water from certain wells spoils the beauty of their teeth. A fluorine content of 1–2 p. p. m. in the drinking water causes mottled enamel. In rural houses where the tooth paste from the market is still a luxury, one of the first morning activities is the brushing of the teeth with thin branches of the Arak tree *(Salvadora persica)*. People in the Sudan are very proud of shiny white teeth, however all efforts of cleaning them well are in vain after they are attacked by dental fluorosis.

Finally the choice of Nile water can be based on economic considerations. In a small town like Abu Haraz in the Gezira Province there are no health objections to the water from their well, but houses close to the Blue Nile can obtain 20 l water for 2 Piaster whereas they must pay a transport fee of 2½ Piaster for the same amount of well water. As a result of this difference the cheaper water is chosen also during the flood season. This attitude is almost always found in households where the women are left alone with their children while the busband has a job in one of the bigger towns no matter whether he is earning a low or a high salary. Only in rural houses of higher government officials and teachers working in the same village may the family be prepared to pay for water quality.

In villages far away from sites of good Rauwaq, wild growing efficient plant coagulants or small markets where seeds from cultivated plants can be purchased some people give up the practice of water purification or do it only occasionally in order to save money.

The quest for apparently "clean water" has to go in parallel with the quest for water with a minimum of faecal pollution (JAHN 1976). This requires not only that efforts are made to make the traditional methods of water purification safer and more efficient by studying the coagulants from a scientific point of view but also that there is an increase in basic health education and improvement of the hygienic standards.

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EINFLÜSSE RÄUMLICHER STRUKTUREN AUF DEN INDUSTRIALISIERUNGSPROZESS IN KOLUMBIEN

Mit 1 Abbildung und 1 Tabelle

WOLFGANG BRÜCHER

Summary: Spatial structural influences on the industrialisation process in Columbia.

According to an opinion widely held in Columbia, the country's limited degree of industrialisation is largely due to its relief, which has led to its being split up into subregions as well as to an extraordinary dispersion of its urban population and industrial capacity. However, this dispersion has been decisively re-inforced by anthropogenic process (agrarian structure, infrastructural opening-up, state industrialisation policies). Whilst it has until now retarded industrial development, this polycentric structure, together with increasing modernisation of the infrastructure, today on the contrary offers more favourable conditions by far for regionally-balanced economic growth than in other monocentrically moulded countries in South America. The government's economic policy of centralisation, however, runs contrary to such an advantageous development.

In Kolumbien ist häufig das pauschale Argument zu hören, die *Unterentwicklung des Landes und ganz besonders sein niedriger Industrialisierungsgrad seien weitgehend auf die reliefmäßige Zergliederung des Landes* und auf die Ausbildung scharf voneinander getrennter Teilräume zurückzuführen. Primär ergibt sich diese Struktur aus der Aufspaltung der Anden nördlich von Pasto in die West-, die Zentral- und die Ostkordillere. Sie scheiden Kolumbien in das östliche Tiefland, die Täler des Magdalena und des Cauca, die in das nördliche Tiefland münden, und die Pazifikebene. Der Kontakt des karibischen Küstensaumes mit dem Landesinnern wird durch ausgedehnte Sumpf- und Überschwemmungsgebiete erschwert. Kleinere Teilräume entstanden in den Längstälern durch Engpässe und Stromschnellen sowie in den Hochbecken der Ostkordillere.

Es ist ein deterministisches Argument, diese naturräumliche Struktur für den geringen Industrialisierungsgrad mitverantwortlich zu machen. Nun sind in der Tat die weitreichenden und vielschichtigen Einflüsse des Reliefs auf weitere sozio-ökonomische Strukturen – beispielsweise auf die Märkte und auf das Verkehrsnetz – nicht zu übersehen. Eine kritiklose Hinnahme und Verallgemeinerung dieser These wäre jedoch fatalistisch und könnte dadurch folgenschwer werden. Deshalb sollen hier drei diesbezügliche Fragenkomplexe behandelt werden:

1. In welcher Weise hatte und hat diese reliefbedingte Gliederung des Landes als Basisstruktur direkte und indirekte negative Auswirkungen auf den Industrialisierungsprozeß?