ANALYSIS RESULTS AND CONCLUSIONS

Figure 1: Sampling Locations (1-5) along the Tinishu Akaki

<u>*Sampling Location 1*</u>

Sampling Location 2

Sampling Location 3

Sampling Location 4

Sampling Location 5

Table 1: Excel screenshot of summarized analysis results

	Sampling Location 1	Sampling Location 2	Sampling Location 3	Sampling Location 4	Sampling Location 5
Sampling Time	9:44 – 10:32	10:50 – 11:25	11:52 – 12:31	12:55 – 13:33	13:48 – 14:10
Current weather	Slightly sunny, few clouds, clear sky	Raising temperatures, very sunny, first rain clouds on the horizon	Very sunny, still clear sky, but rapidly approaching rain clouds on the horizon	Falling temperatures, cloudy sky	Very cloudy sky, drizzle and light rain
Organoleptical Water Analysis	Slightly feces-like odor, few recognizable particles, high turbidity, milky grayish color	Intensive feces-like odor, few recognizable particles, high turbidity, milky grayish color	Very intensive feces-like odor, slightly frothy surface, few recognizable particles, very high turbidity, brownish color	Intensive feces-like odor, slightly frothy surface, few recognizable particles, high turbidity, brownish color	Slightly feces-like odor, frothy surface, few recognizable particles, high turbidity, brownish color
Air Temperature [°C]	20,2	26,1	23,5	23,2	19,5
Water Temperature [°C]	17,6	19,0	21,2	23,0	22,8
Electric conductivity [µS/L]	865	310	305	296	298
PH Value [strips]	6,5	6,5	6,0	6,0	6,0
Ammonium (Visocolor) [mg/L]	0,8	0,4	0,4	0,5	0,1
Nitrite (Visocolor) [mg/L]	0,3	0,6	2,0	0,2	0,2
Nitrate (Visocolor) [mg/L]	11,0	12,0	40,0	3,0	6,0
Phosphate (Visocolor) [mg/L]	23,0	23,0	25,0	25,0	6,0
Chlorid (Quantofix) [mg/L]	0-500	0	0	0-500	0
Sulfate (Quantofix) [mg/L]	200-400	< 200	< 200	< 200	< 200
Other	Sampling point very close to a bridge near source point, relatively low flow rate/water supply, pure residential area, already high waste pollution and wastewater inflow through local Households	Sampling point in a slightly expanded riverbed, very low water depth/flow rate/water supply, pure residential area, High waste volume	Sampling point under a bridge, heavily constrained riverbed, higher water supply/flow rate, scattered turbulences, pure residential area, extremely high waste and fecal volume	Sampling point in an expanded, heavily overgrown riverbed, higher flow rate/water supply, concentrated turbulences, both residential and business area, extremely high waste volume (adjacent dump)	Sampling point outside the city center in an expanded greenbelt, agricultural acreage on both sides, high flow rate/water supply, many turbulences, stones and cascades, significantly less waste volume than before

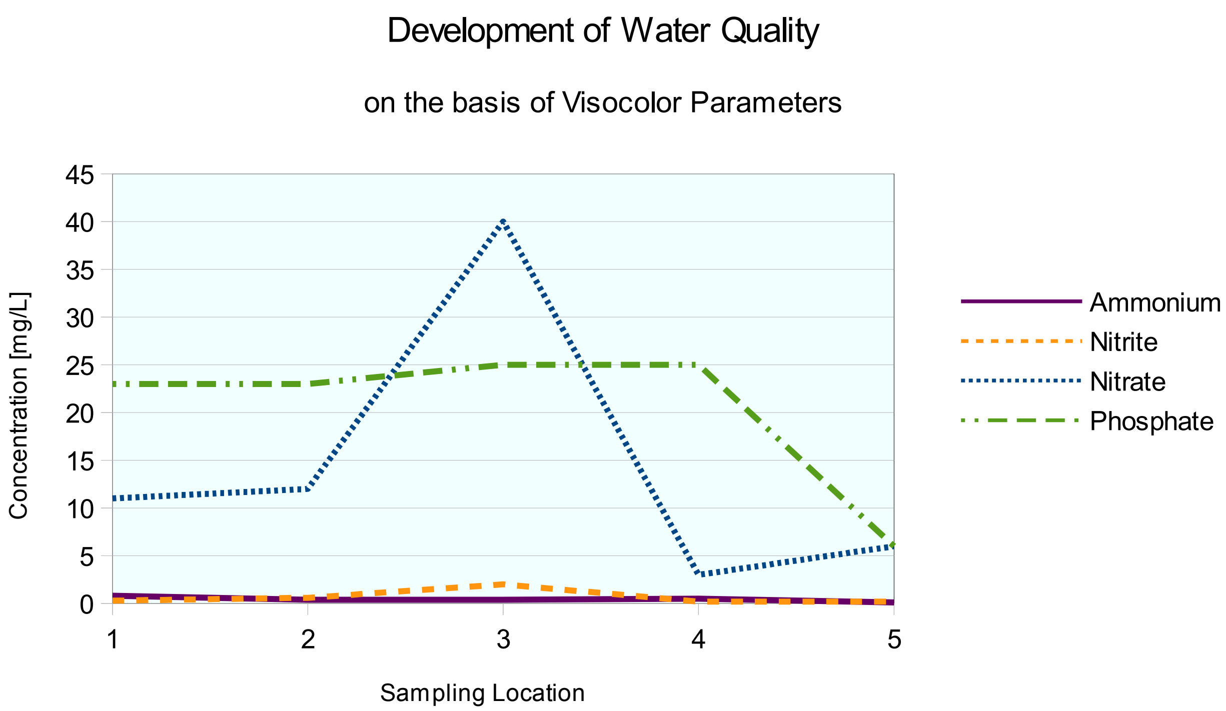

Figure 2: Concentration development of Ammonium, Nitrite, Nitrate and Phosphate

Electric Conductivity

Background: Measure of the total dissolved ions in a water body and thus an indication of the water's mineralization degree. Significantly increased conductivities give already an indication of contaminating effects. Higher temperatures do also lead to increased conductivity values as more and more water-soluble substances go then in solution. Values > 750 µS/L indicate anthropogenic influences.

Results: Except for Sampling Location 1 (865 µS/L) relatively low electric conductivity values in the Tinishu Akaki were measured. There is obviously a low presence of salts, acids and bases that would significantly increase the mineralization degree of the river water. Geogenic influences appear to have little to no greater impacts within the urban area. This seems to be the case only at the river's point of origin, where anthropogenic exposure might be involved as well.

PH Value

Background: The pH value of unpolluted water should be in the neutral, very weakly acidic or alkaline range. The flora/fauna of a water body greatly depends on the pH, since many organisms prefer an acidic or an alkaline environment. Even slight deviations from the norm might be of decisive importance for biological processes in the water. The same principle applies to the human metabolism where minor changes (i.e. by overloading the buffering capacity) of the pH in the blood (on average about 7.4) can lead to massive disturbances, which even might be life-threatening. The pH also affects the water solubility of some pollutants.

Results: The measured values are in the weakly acidic range (6.5), but tend downriver to more acidic milieus (6.0). For human consumption the river water would already be too acidic, it would be questionable even as bathwater.

Ammonium

Background: The detection of ammonium ions indicates hygienically questionable impurities, i.e. caused by domestic/industrial waste waters, manures, compost and/or slurry. Therefore, ammonium is mainly washed out from agricultural land, contaminated sites and landfills. In larger amounts it tends to go into ammonia that (when exceeding critical limits) can carry harmful to lethal effects on both human beings, fish and other small river organisms.

Results: The ammonium concentrations in the Tinishu Akaki are mostly above or close to potential damage limits for people and living river organisms. Given this parameter only, the river water would not be suitable for drinking water purposes.

Nitrite

Background: Nitrite is considered as an indicator of water pollution, refers to a still ongoing nitrification process, and is among the most carcinogenic substances. Nitrite is a metastable and relatively toxic intermediate in the bacterial oxidation chain proteins – ammonium – nitrite – nitrate. Higher concentrations exhibit rotting or putrefication foci in the soil (rubbish dumps, septic tanks, etc.). Industrial and municipal waste water may often cause concentrations between 0.5 mg/ L and 1.0 mg/L, due to the degradation of living matter.

Results: Particularly in the case of Sampling Location 2 and 3 alarmingly high nitrite concentrations were registered. Above all, the central flow section seems to suffer from a strong nitrite poisoning, probably caused by massive impacts of/contamination with domestic waste waters, feces and organic waste.

Nitrate

Background: The nitrate content is another important measure of the nitrogen pollution of a river. Nitrate levels < 10 mg/L are i.a. due to geogenic origin, while levels of 15 mg/L to 50 mg/L already point to human influence. The most relevant entry sources are (in)organic nitrogen fertilizer (i.e. manures, ammonium nitrate), landfill leachates and wastewater seepage. Nitrate is for human beings primarily non-toxic. However, it can be secondarily reduced to toxic nitrite in the stomach, which can result, especially in the case of toddlers and infants, to cyanosis (hemoglobinemia). Furthermore, as tertiary transformation products nitrous compounds might be formed, which are carcinogenic. They occur in the human body from nitrite and amines.

Results: The recorded nitrate levels in the Tinishu Akaki are generally not serious, although there seems to be a sharp increase around Sampling Location 3. In this environment, water consumption might be classified as doubtful, in terms on nitrate only.

Phosphate

Background: Phosphate levels < 0.05 mg/L generally have geogenic origins, whereas higher levels indicate anthropogenic influences. This can, for example, be due to agricultural manures and detergent wastewater infiltration (lack of or defective sewer sections). The phosphate disease is based on an oversupply of phosphate in the human body, especially in the case of children, and manifests itself in morbid hyperactivity. The most important remedial action is seen in the reduction of phosphate uptake in nourishment.

Results: At the Sampling Locations 1-4 extremely high phosphate contents were registered (23 mg/L to 25 mg/L). This might be due to the high detergent supply in the domestic wastewater. The concentrations seem to decrease first outside the city center, as at Sampling Location 5 only 6 mg/L were measured. Consequently, there is an enormous phosphate disease risk, primarily within the densely populated city center.

Chlorid

Background: Chlorid usually refers to the salt loads in a water body. Contents of 15 mg/L to 50 mg/L indicate human influence, the main entry source are agricultural fertilizers.

Results: Along the whole examined river section no significant chlorid loads were found. Therefore, the relatively low salinity would partly confirm the measurement results of the parameter Electric Conductivity, which are quite low, too.

Sulfate

Background: Higher sulfate concentrations (< 70 mg/L) indicate anthropogenic influence, especially when in the river water increased levels of chloride, nitrate and phosphate are monitored as well. Sulfate is the lead-ion for the leaching from building rubble deposits such as plaster and gypsum. Another entry can be made of sulfate-containing fertilizers and pesticides. In the human body, the supply of poorly resorbable water constituents such as sulfate leads, via an osmotic water retention, to a liquefaction of the intestinal contents with increased rinsing action. At the same time, the conditions for receiving the substances contained in the intestine are deteriorated.

Results: Analogously to chlorid, there were no significant sulfate concentrations found in the Tinishu Akaki. As the river flows mainly through marginal settlement areas, there are only few modern buildings that might contain higher amounts of gypsum or plaster.

Conclusions

Overall, it turned out that the Tinishu Akaki is an extremely polluted river, as the first analysis results show. This is primarily due to the alarmingly high nitrite and phosphate levels that are far above the limits of ecologically compatible water bodies. The other parameters might not be present in similarly harmful concentrations, but definitely restrict a worry-free utilization in terms on human consumption. In addition, large accumulations of waste (organic, plastic, bottles, scrap etc.), feces and domestic waste water/sewage inflow were found in the immediate vicinity of the inner-city Sampling Locations, both in the river water and the shore. The river banks are mostly either heavily eroded or were replaced by high channel walls, which impede an direct access and disturb natural flow patterns. Altogether, there is a very high need for immediate river cleaning actions. It would, however, be interesting to examine the water of the Tinishu Akaki to additional parameters (i.e. Oxygen Content, Chemical and Biological Oxygen Demand, Hardness, etc.), in order to draw more accurate conclusions about the quality.