J. Int. Environmental Application & Science, Vol. 11(4): 384-390 (2016)

Evaluation of Physico-chemical Parameters of the Lumëbardhi of Deçani River and Radoniqi Lake, Kosova

Nushe Lajçi[1,*], Blerim Baruti[1], Florent Dobroshi[1], Ali Sadiku[2]

[1]*Faculty of Food Technology, University of Mitrovica 40000, Mitrovicë, Kosova;* [2]*Faculty of Geosciences and Technology, University of Mitrovica, 40000, Mitrovicë, Kosova*

Received September 25, 2016; Accepted December 19, 2016

Abstract: Rivers and lakes are the most valuable natural resources for human beings. Unfortunately despite of its importance, fresh water resources are being polluted by disposable of sewerage, industrial effluents, municipal waste, mining activity, agricultural activity and other different types of waste into the river/lakes. The objective of this study was to assess physico-chemical parameters of the Lumëbardhi of Deçani River as a main water supplier of Radoniqi Lake during the year, 20015. The variations of water quality parameters along the river courses (upper, middle and lower course), between seasons and in lake were examined. The majority of the parameters showed that there is significant variations of the water quality parameters between the winter and summer seasons. However, the variations along the river courses sampling site (upper, middle and lower course) were higher at the middle sampling site in urban areas. This implies that the water quality is influenced more by anthropogenic impacts in the middle course of the river. The physicochemical parameters analyzed in Radoniqi Lake lie within the permissible range and it is a good quality for drinking after treatment, irrigation and fish culture purposes.

Keywords: *Lumëbardhi of Deçani River, Radoniqi Lake, physico-chemical parameters, pollution, seasonal variation*

Introduction

Water is one of the most fundamental valuable natural resource on earth for survival of life and metabolic process of all living organisms. It is essential to human being, animals, plants and without water life on earth would not exist. Water quality plays an important role in the overall water balance of the environment. Rivers are water ways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purposes. They are prime factors controlling the global water cycle and in the hydrologic cycle (Garrels *et al*., 1975). The quality and quantity of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks and anthropogenic changes that curtail natural flow of the river, or alter its hydrochemistry (King *et al*., 2003).

With rapid growing population, industrialization and improved living standards, the pressure on water resources is increasing. The quality of water is affected by natural processes and an increase in anthropogenic activities. The wastewater from industry, domestic, agriculture and runoff surface water affect the water quality by their colour, high organic content, widely varying pH and other pollutants (Jackson *et al*., 2001). Safe drinking water is necessary for proper health care and significant socio-economic development. Fresh water is already a limiting resource in many parts of the world. The World Health Organization estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water (WHO, 1997).

Access to safe drinking water and sanitation is a global concern. Kosova suffers from a lack of access to safe drinking water from improved sources and to adequate sanitation services. As a result, people are still dependent on unprotected water sources such as rivers, streams and lakes. The aim of this research was to determine the physico-chemical characteristics of the Lumëbardhi of Deçani River as a main water supply of artificial Radoniqi Lake. Radoniqi Lake is major sources of water supply for the people of Gjakova Region, Kosova. Water from this source is used for drinking, other domestic purposes and irrigation.

Corresponding: E-Mail: nushe.lajqi@umib.net; Tel: +37744221107; Fax: +38139432124

Materials and Methods

Study area and sampling sites

The River Lumëbardhi of Deçani, originates from the "Bjeshkët e Nemuna" mountain (latitude: 42°31'01", longitude: 20°32'35"). In geomorphologic point of view is characterized by gorges, valleys, karst phenomena, glacial, fluvioglacial and denudation. It forms a narrow valley and deep sloping upstream average 80 m/km and has a length of 53 km. Lumëbardhi of Deçani River is right tributary to the White Drini River flows entirely within the western part of Kosova. In the upper course, the waters of the river are used for the Kozhnjer Hydroelectrical Power Plant (6.5 MW). Lumëbardhi of Deçani River is a main water supplier of Radoniqi Lake of about 90%.

The Radoniqi artificial Lake was raised in dam of river Përrua in village Radoniq, north of the town of Gjakova (latitude: 42°29′15″N, longitude: 20°25′05″E). Lake is the main supply source of drinking water to Gjakova town area and many rural and other urban communities after treatment. It is used also for irrigation for villages under the irrigation canal Radoniqi. It is one of the most productive lakes with respect to aquatic ecosystems. It has a surface area of 644 hectare (km^2). It is one of the largest freshwater lakes in Kosova. It has been well known for its scenic beauty and richness of aquatic life.

Physico-chemical analysis

Water samples were collected once every month during January-2015 to December-2015 from Lumëbardhi of Deçani River and the Radoniqi Lake on the basis of upstream to downstream and in the lake. Five sampling points were chosen for river quality monitoring and lake. Sampling point (S1) is near Kozhnjer, representing the background values, i.e. with little interference from anthropogenic activities. Sampling point (S2) in the downstream near Monastery of Deçani, on which farming are the major activities. Sampling point (S3) is near Dema Bridge (in Deçani town) which reflects the impact of domestic discharge water and sewage of the Deçan town. Sampling point (S4) is near derived channel, at the entry of river water in the lake and sampling point (S5) in the Radoniqi Lake.

The physico-chemical tests included the determination of temperature, pH, dissolve oxygen, electrical conductivity, turbidity, total hardness, ammonia, nitrate, nitrite, phosphate, sulphate, iron and manganese content were conducted following APHA (2005) procedures. The water samples were collected using sampler from a depth of 30 cm below from the surface of water and thoroughly cleaned and rinsed three times with river water to be collected in two litters polythene bottle. The field parameters like temperature, pH, electrical conductivity, dissolve oxygen were determined immediately after the collection of samples at field using field water analysis apparatus. For further analysis of physico-chemical the samples were transported to the laboratory in the ice box. The samples were stored in the refrigerator till analysis. Turbidity was measured by the nephelometric method (NTU) using Turbiquant Turbidimeter 1500 T. Total hardness was determined by EDTA titration, using Erichrome Black T indicator. Ammonia, nitrate, nitrite, phosphate and sulphate were measured by photometric method using Spectroquant NOVA 60 (Merck). Iron and manganese were determined by a colorimetric method using a UV-Visible 1650 spectrophotometer.

Results and Discussion

The mean values of physico-chemical along the Lumëbardhi of Deçani River, in Radoniqi Lake and season variation water of parameters in the river during 2015 are given in tables 1, 2 and 3. The values of physico-chemical parameters have been evaluated with respect to guidelines provided by World Health Organization (WHO, 2008) and European Community (EC, 1998) to indicate the pollution level of Lumëbardhi of Deçani River and Radoniqi Lake.

Water temperature controls the rate of metabolic activities, reproductive activities and life cycles. It impacts the physical and biological characteristic of water (El-Jabi *at al.*, 2006). The rise in temperature of water accelerates chemical reactions, reduces solubility of gases, amplifies taste and odour and elevates metabolic activity of organisms (Carr & Neary, 2006). The variations of temperature at all sites along the downstream of the river Lumëbardhi of Deçani (S1-S4) were insignificant (10.4 to 10.6^oC) (table 1). The mean annual water temperature of the lake was 9.1^oC (Table 2). Temperature values for this present study showed marked seasonal variation (Table 3). The variations of temperature of the river among the sampling season were 4.8˚C (winter) to 17.2˚C (summer). The drop in water temperature in the winter season month is attributable to heavy rainfall experienced during the study period. Higher temperature values recorded in the summer season months are expected since heat from sunlight increases temperature of surface water. Water temperatures in this study was found lower compared to WHO, (2008) and EU, (1998) permissible limit.

Table 1. The mean value of physico-chemical parameters along the Lumëbardhi of Deçani River during 2015

Parameters	Kozhnjer	Monastery of Deçani	Dema Bridge	Derived channel	Average
Temperature (^oC)	10.4	10.5	10.6	10.6	10.525
pH	7.71	7.77	7.79	7.76	7.7575
Dissolved oxygen, mg/l	11.4	11.2	10.5	10.7	10.95
Conductivity, μS/cm	223	228	229	232	228
Turbidity, NTU	7.4	9.1	11.4	10.5	9.6
Total hardness, ^{0}dH	7.0	7.14	7.14	7.28	7.14
Ammonia, mg/l	0.1	0.14	0.23	0.19	0.165
Nitrate, mg/l	0.44	0.56	0.69	0.65	0.585
Nitrite, mg/l	0.005	0.007	0.01	0.008	0.0075
Phosphate, mg/l	0.07	0.12	0.19	0.15	0.1325
Sulfate, mg/l	19	19.5	21.5	21	20.25
Iron, mg/l	0.03	0.085	0.195	0.15	0.115
Manganese, mg/l	0.05	0.075	0.095	0.090	0.0775

pH (hydrogen ion concentration) of water is important for the biotic communities as most of the plant and animal species can survive in narrow range of pH from slightly acidic to slightly alkaline condition (Chapman, 1996). The pH of Lumëbardhi of Deçani River at all sites ranged from a minimum of 7.71 at (S1) to a maximum of 7.79 at (S3). The increase of pH value recorded at sampling site S3 could be attributed to the increase in the anthropogenic activities along the water body. The pH of the water lake was 7.78 (Table 2). The measured pH of the water reflected the changes corresponding to the sampling seasons (table 3). The pH of water was higher during the summer season (7.82) and lower during winter season (7.59). The pH value in the present investigation showed slightly alkaline condition. The EU sets protection limited of pH from 6 to 9 for fisheries and aquatic life. The pH of river at all sites and lake was found within the permissible limits standards.

All aquatic organisms needs dissolved oxygen (DO) at the required concentration to survive, it is very essential for the metabolism of aquatic organisms. At low and moderate temperature, oxygen tends to be soluble in water forming equilibrium between the dissolved oxygen and atmospheric oxygen. Generally, dissolved oxygen concentration is a product of activities in the water, higher biological activities lower DO concentration. Dissolved oxygen considered the critical parameter for distinction the health of an aquatic ecosystem and is usually use as a water quality indicator (Budget *et al*., 1985). The higher level of dissolved oxygen along the river was 11.4 mg/l at (S1) while the lowest values recorded was 10.5 mg/l at (S3). The mean value of DO of the water lake was 9.93 mg/l (Table 2). The decease of DO at (S3) may be due organic waste. DO values showed seasonal variations. The lowest value of dissolved oxygen was 10.3 mg/l during summer, while higher level during the winter season was 11.9 mg/l. The variation in DO might be due to temperature, photosynthesis, respiration, aeration, organic waste and sediment concentration. The permissible limit of the DO in drinking water should be ≥6 mg/l.

Water capability to transmit electric current is known as electrical conductivity and serves as tool to assess the purity of water. This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentrations and temperature. The variations of conductivity along the river varied from a minimum of 223 μS/cm (upstream, S1) to a maximum of 232 μS/cm (downstream, S3). The mean value of electrical conductivity of the lake was 229 μS/cm. Conductivity values showed seasonal variations. The lowest electrical conductivity was reported during winter 229 μS/cm due to the water dilution by rainy water into the river and highest in summer season 242 μS/cm because of domestic effluent discharges from Deçani town and surface run-off from the cultivated fields which might have increased the concentration of ions. All samples complied with WHO and EU standards.

Table 2. The mean value of physico-chemical parameters of the Radoniqi Lake during 2015

Parameters	Radoniqi Lake water/2015
Temperature (^oC)	9.1
pH	7.78
Dissolved oxygen, mg/l	9.93
Conductivity, μS/cm	229
Turbidity, NTU	4.2
Total hardness, ^{0}dH	7.42
Ammonia, mg/l	0.16
Nitrate, mg/l	1.62
Nitrite, mg/l	0.0075
Phosphate, mg/l	0.076
Sulfate, mg/l	20.5
Iron, mg/l	0.21
Manganese, mg/l	0.062

Turbidity in aquatic environment is caused by suspended and colloidal matter, such as clay, silt, finely divided organic and inorganic matter, plankton and other microbial organisms (APHA, 2005). Results also showed that the turbidity values of water sample varied significantly across the sampling site and between seasons. As shown in table 1, the turbidity value was lowest at the upstream S1 (7.4 NTU) and highest at S3 (11.4 NTU). This rise in turbidity may be attributed to the presence of material related to municipal, industrial or other discharges which produce turbidity and present in the untreated effluent. The mean value of electrical turbidity of the lake was 4.2 NTU. Turbidity values of river water showed marked seasonal variation (Table 3). Turbidity values ranged from a minimum of 3.8 NTU in winter season to a maximum of 17.4 NTU in summer season (Table 3). From all samples, 2 samples (3.8 NTU, 4.2 NTU) at S1 and in lake water, were found with the WHO guideline permissible limit value (< 5NTU). Therefore, turbidity is the main water quality concern of river and it makes the water non suitable for direct domestic use. High turbidity can be associated with high soil erosion from poor farming practices which result in large quantities of top soil ending up in the river after heavy rains.

The total hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. Principally the water hardness is changed by ions such as calcium and magnesium. High levels of hard water ions such as Ca^{2+} and Mg^{2+} can cause scaly deposits in plumbing, appliances and boilers. High levels of total hardness are not considered a health concern. On the contrary, calcium is an important component of cell walls of aquatic plants, and of the bones or shells of aquatic organisms. Magnesium is an essential nutrient for plants, and is a component of chlorophyll. Total hardness values ranged from a minimum of 7.0 ^{0}dH at S1 (upstream) to a maximum of 7.28 ^{o}dH at S4 (downstream). Total hardness of the water lake was 7.42 ^{0}dH (table 2). Total hardness values ranged from a minimum of 7.14 ^{0}dH during winter season to a maximum of 7.28 ^{0}dH during summer season. Great amount of magnesium imparts a repulsive taste to the potable water (Piska, 2000), but in the current study the concentration was found within the permissible limit of EU and WHO standards.

The minimum ammonia value along the river (0.1mg/l) was recorded at S1 while the maximum ammonia value (0.23 mg/l) was recorded at S3. Elevated concentrations of ammonia are more commonly associated with urban waste. The minimum ammonia value (0.05mg/l) was recorded during winter season while the maximum ammonia value (0.25 mg/l) was recorded during summer season. The mean concentration of ammonia in the lake water was 0.16 mg/l complied with WHO guideline value (1.5 mg/l).

Table 3. Mean season variation of physico-chemical parameters of the Lumëbardhi of Deçani River during 2015

Parameters	**Jan. - March**	**April - June**	**July - Sept.**	**October -Dec.**	**Average**
Temperature (^oC)	4.8	10.2	17.2	9.8	10.5
pH	7.59	7.79	7.82	7.74	7.735
Dissolved oxygen, mg/l	11.9	11.2	10.3	10.4	10.95
Conductivity, μS/cm	229	221	242	222	228
Turbidity, NTU	3.8	17.4	6.3	10.8	9.6
Total hardness, ^{o}dH	7.14	7.14	7.28	7.0	7.14
Ammonia, mg/l	0.05	0.18	0.25	0.13	0.153
Nitrate, mg/l	0.33	0.55	0.61	0.49	0.495
Nitrite, mg/l	0.0025	0.0095	0.015	0.0065	0.0084
Phosphate, mg/l	0.055	0.085	0.17	0.10	0.1025
Sulfate, mg/l	17.5	21.5	23	19	20.25
Iron, mg/l	0.065	0.14	0.16	0.095	0.115
Manganese, mg/l	0.045	0.08	0.089	0.081	0.074

Nitrates are contributes to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields (Solanki, 2012). Ammonium sulphate fertilizers are widely used by farmers in agricultural areas and nitrates are more frequently used as the organic and inorganic fertilizers (Vega *et al*., 1998). As a result, fertilizers can be transported through irrigation water and runoff into river and lake. The amount of ammonium, sulphate and nitrate in the river has increased. Nitrate fertilizers in agricultural areas are the most common. In particular, pesticides and agricultural nitrate fertilizers containing nitrogen and phosphorus contribute to pollution. In addition, total phosphorus runoff from the agricultural areas causes pollution in the river. The highest amount of nitrate concentration was known to support the formation of blooms (Uduma, 2014). Excessive nitrate can give rise to two problems: infantile methaemoglobinaaemia and the formation of nitrosamines. The amount of nitrate recorded in the water of river ranged from minimum of 0.44 mg/l at S1 (upstream) to a maximum of 0.69 mg/l at S3 (downstream). The amount of nitrate recorded in the water of lake was 1.62 mg/l. The lowest amount of nitrate recorded during winter season was 0.33 mg/l, while the highest amount of nitrate during summer season was 0.61 mg/l. Though the values are within the maximum permissible limits but there was an increase from upstream to downstream.

Nitrite exists normally in very low concentrations because the nitrogen will tend to exist in the more reduced (ammonia) or more oxidised (nitrate) forms. The nitrite value ranged from a minimum value of 0.005 mg/l along the river at site S1 to a maximum of 0.01 mg/l at S3. Nitrite is generally unstable in aerated water and elevated concentration of nitrite is indicator of possible sewage pollution. High presence of nitrite results from leaching or run-offs from agricultural land and contamination from human waste or animal waste. The annually mean value of nitrite recorded in the water of lake was 0.0075 mg/l. The nitrite value ranged from a minimum value of 0.0025 mg/l during winter season to a maximum of 0.015 mg/l during summer season. Nitrite values were below the permissible limits.

Concentration of phosphate in river water was low. Lowest levels were observed at S1 (0.07mg/l), but the levels increased in the downstream with progress to sites S2–S3 (0.19 mg/l). The phosphate value ranged from a minimum value of 0.07 mg/l at (S1) to a maximum of 0.19 mg/l at (S3). The higher level of phosphate (0.19 mg/l) was found in the river water where it receives maximum sewage, domestic wastes and human activities. Use of detergent may increase the phosphate concentration to great extent. Phosphate increased at all points with the progress of the season which indicates that the phosphate source could be the fertilisers used in the farms. The higher levels also could be attributed to the decreased flux in the river due to seasonal variations. The annually mean value of phosphate recorded in the water of lake was 0.076 mg/l. The phosphate value ranged from a minimum value of 0.055 mg/l during winter season to a maximum of 0.17 mg/l during summer season. The high value of phosphate during summer season is mainly due to rain, surface water runoff, agricultural runoff, washer man activity could also have contributed to the inorganic phosphate content; as well as continuous entry of domestic sewage in some area are responsible for increase in amount of phosphate. Phosphate values were below than the permissible limit.

Sulphate mainly is derived from the dissolution of salts of sulphuric acid and abundantly found in almost all water bodies. Sulphate concentration in natural water ranges from a few to a several 100 mg/l, but no major negative impact of sulphate on human health is reported. The WHO has established 250 mg/l as the highest desirable limit of sulphate in drinking water. The concentration of sulphate along the river ranged from 19 mg/l (S1) to 21.5 mg/l (S3). The higher value at S3 could be due to discharge from waste disposal, domestic waste and untreated sewage. The mean value of sulphate in the lake was 20.5 mg/l. The concentration of sulphate in river water was lower during winter season (17.5 mg/l) and higher during the summer season (23 mg/l). The presence of sulphate in drinking-water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers. The values of sulphate concentration were within the maximum permissible limits.

Iron is an essential element in human nutrition. The shortage of iron causes disease called “anemia”. Although iron is an essential mineral, prolonged consumption of drinking water with high concentration of iron may lead to liver disease called haermosiderosis, diseases of aging such as Alzheimer’s disease, other neurodegenerative diseases, arteriosclerosis, diabetes mellitu (Brewer, 2009). High concentrations of dissolved iron can result in poor tasting, unattractive water that stains both plumbing fixtures and clothing (Colter & Mahler, 2006). The variations of iron concentration along the river varied from a minimum of 0.03 mg/l (upstream, S1) to a maximum of 1.95 mg/l (downstream, S3). The mean value of ion in the lake was 0.21 mg/l. The minimum iron value of 0.065 mg/l was recorded during winter while the maximum iron value (0.16 mg/l was recorded during summer. The values of iron concentration were within the maximum permissible limits.

Manganese concentration levels along the river sampling site ranged from a minimum 0.05 mg/ l at (S1) to maximum 0.095 mg/l at (S3). This rise in manganese concentration may be attributed to the presence of material related to municipal, industrial or other discharges. The mean manganese concentration of the lake water was 0.062 mg/l. Manganese concentration in the river showed marked seasonal variation. The lowest manganese concentration was during winter (0.045 mg/l) due to the water dilution by rainy water into the river and highest in summer season (0.089 mg/l) because of domestic effluent discharges and surface run-off from the cultivated fields. All the samples were below than the permissible limit of EU and WHO standards. At higher concentration levels (higher than 0.1 mg/l), manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking-water may also lead to the accumulation of deposits in the distribution systems (Teng *et al*., 2001).

Conclusions

On the basis of findings, it can be concluded all the physico-chemical parameters of the samples were lower in winter and higher in summer. However, the variations of parameters along the river courses Lumëbardhi of Deçani were higher at the S3. This was as a result of highly populated area and an increase in anthropogenic activities. Direct discharge of untreated domestic waste into the river was responsible for the high organic pollution values in the middle sites (S3), which were gradually reduced in the downstream sites due to self purification and has potential for significant improvement in water quality if discharges are ameliorated. Comparing with the World Health Organization and EU Standard, the results indicated that the physico-chemical parameters were within acceptable limits for human consumption and irrigation purposes except turbidity. While physicochemical parameters analyzed in Radoniq Lake were in compliance with the WHO and EC standards. Therefore lake water for domestic purpose needed more treatment for human purposes, and it also suggested to be protected from different contaminations.

References

APHA, (2005) American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*, 21st Ed. Washington, DC.

Brewer G, (2009) Risks of Copper and Iron Toxicity during Aging in Humans, *Chem. Res. Toxicol,* **2**, 319-326.

Budget US, Verma AK, (1985) Limnological studies on J.N.U. Lake, New Delhi, *India. Bull. Bot. Soc. Sugar*, **32**, 16-23.

Carr GM, Neary JP, (2006) *Water Quality for Ecosystem and Human Health*. United Nations Environment Program Global Environment Monitoring System/Water Program. Burlington, Ontario, Canada.

Chapman D, (1996) *Water Quality Assessment-A guide to use of biota, sediments and water environmental monitoring* 2nd Ed. EPFN Spon, London.

Colter & Mahler, (2006) *Iron in Drinking Water*. University of Idaho. A Pacific Northwest Extension.

El-Jabi N, Daniel C, Noyan T, (2014) Water Quality Index Assessment under Climate Change. *J. of Water Resource and Protection*, **6**, 533-542.

EU's drinking water standards, Council Directive 98/83/EC on the quality of water intended for human consumption, Adopted by the Council, 3 Nov., 1998.

Garrels RM, Mackenzie FT, Hunt C, (1975) Chemical Cycle and the Global Environment, William Kaufman, New York.

Jackson RB, Carpenter SR, Dahm CN, McKnight DM, Naiman RJ, Postel SL, Running SW, (2001) Water in a Changing World, Issues in Ecology, *The Ecological Society of America, Washington*, **9**, 1-16.

King JM, Scheepers ACT, Fisher RC, Reinecke MK, Smith LB, (2003) River Rehabilitation: Literature Review, Case studies and Emerging Principles. *WRC Report No.* 1161/1/03.

Piska RS, (2000) Concepts of Aquaculture, Lahari Publications, Hyderabad.

Solanki HA, (2012) Status of soils and water reservoirs near industrial areas of Baroda: pollution and soil - water chemistry. *Lap Lambert Academic Publishing*, Germany.

Teng Z, Fujita K, Takizawa S, (2001) Manganese removal by hollow fiber micro-filter. Membrane separation for drinking water, *Desalination*, **139**, 411-418.

Uduma AU, (2014) Physico-chemical analysis of the quality of sachet water consumed in Kano metropolis. *Am. J. Environ., Energy & Power Res.*, **2,** 1-10.

Vega M, Pardo R, Barrato E, Deban L, (1998) Assessment of seasonal and polluting effects on the quality of river water by exploratory data analysis. *Water Research*, **32**, 3581-3592.

WHO (World Health Organization) 2008. Guidelines for drinking-water quality. V. 1, Recommendations 3rd Ed., incorporating first and second addenda, Geneva.

WHO (1997) *Basic Environmental Health*, World Health Organization Geneva.