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Hydrology at Technical Universities

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Finnish engineering hydrological research has its roots in agrohydrology. The purpose of the research has been to give answers to forthcoming problems and therefore it has usually focused to applied hydrological research.

Helsinki University of Technology was founded in 1849 as Polytechnic Institute and got the university status in 1908. Civil Engineering Department had two study programmes, of which one was agricultural water management. The person responsible for research and teaching was I.A. Hallakorpi. He was appointed a professor by the President of the Republic in 1925. Professor Hallakorpi had already published a Finnish textbook "Drainage" in 1917, in which he had presented knowledge of that moment needed for designing drainage systems. Although assessment of drainage benefits was the speciality of professor Hallakorpi, he also carried out extensive water management research. His most significant achievement in hydrology was the formula for estimation of mean high flow, published in 1934.

Professor Hallakorpi was a passionate advocate of agriculture. An example of this is a dispute between him and Dr. Henrik Renqvist. Dr Renqvist had claimed at the 5th Baltic hydrological conference in 1935 that drainage increases discharges in lower stretches of watercourses. Applying statistics used by Renqvist, Hallakorpi proved that such increases had not happened. He wrote irritated: "It is natural that water does not flow more rapidly than it is raining or snow is melting. Digging ditches or dredging streams does not change that."

During the Hallakorpi era two engineers achieved doctor's degree. The first was Lauri Keso, a fiery promoter of sub-surface drainage in Finland and the first Managing Director of the Finnish Drainage Association. His thesis dealt with effects of soil types on drain spacing. In 1925 some experimental drained fields were established due to his actions. In these areas meteorological and hydrological measurements were carried out among others. The research on acid soils published in 1940 can be considered the most significant scientific achievement of Dr Keso.

The other doctor was Pentti Kaitera, who succeeded Hallakorpi in 1942. Dr. Kaitera was the head of the Soil and Hydrotechnical Research Bureau of the Board of Agriculture since the beginning of 1930s. His research dealt with the melting of snow and its influence on the discharge in streams and rivers. He soon became a highly respected ex-

pert in hydrology. In 1936 he was appointed a member of so called Flood Committee, in which the most prominent national expertise in the field of hydrology was united. The chairman of the Committee was Dr. Renqvist and other members were counsellor of forest Axel Cauton and chief engineer Richard Gylling. Dr. Kaitera acted as a secretary of the Committee. After a thorough analysis the Committee concluded that floods in Finland were not generally risen.

Dr. Kaitera started his work as a professor of agricultural water management after the Continuation War in autumn 1944. The first dissertation made under his guidance was the one written by Taneli Juusela in 1945. It dealt with the effect of drainage on soil moisture, ground frost and soil temperature. Two years later Matti Wäre made his dissertation by representing observations from Maasoja experimental field. The next candidate was Kauko Niinivaara who defended his thesis on areal evapotranspiration in 1953. During this period professor Kaitera worked out also two remarkable research papers, one on the method for evaluation of mean-high-flow and the other on hydrological effects of bog drainage. The most important effort in the 1950s was the construction of a laboratory in Otaniemi.

In 1960s the professorship of agricultural water management was renamed as hydrology and water resources management. At that time more emphasis was put on water quality aspects in teaching and research. Also detailed research on hydrological processes was regarded important and a lysimeter field was established in Otaniemi for studies on evapotranspiration and soil water physics. But statistical methods were used as well. Eero Kajosaari published in 1968 his dissertation on droughts and Jussi Hooli analysed in 1971 the effect of meteorological factors on crop yield. In this study he discussed problems of both evapotranspiration and soil water. Ibrahim Güler, who made his research on hydrometeorological and water balanced studies in Finland in 1975, was the last one under the guidance of professor Kaitera.

In 1970s hydrological studies were carried out in all three professorships of water engineering at Helsinki University of Technology. After professor Kaitera's retirement his chair was occupied by Dr. Jussi Hooli in 1975. At that time studies were directed more and more to water quality problems. Siuntiojoki watershed was chosen a research area of the laboratory and many studies were based on the measurements collected there. In the laboratory of hydraulics Laila Hosia investigated head losses in small streams. Professor Harri Sistonen was the head of the laboratory. Matti Melanen was involved in urban hydrological studies in the laboratory of water supply and sewerage, that was headed by professor Eero Kajosaari. Ms. Hosia defended her thesis in 1983 and Mr. Melanen the year before.

Dr. Pertti Vakkilainen was appointed professor of hydrology and water resources management in 1983. He had got his doctor's degree at University of Oulu in previous year. His thesis was based on observation material collected at the lysimeter field in Otaniemi. Since 1980s the hydrological research activities in the laboratory have dealt with statistical, conceptual and physically based hydrological models. Special attention

has been paid on soil and ground water, their retention, movements and quality. In this respect the capability was remarkably strengthened when Helsinki University of Technology appointed Dr. Tuomo Karvonen associate professor of the laboratory in 1994. Two years earlier, laboratories of hydrology and water resources management and hydraulic engineering were united as one.

In 1990s the focus in the hydrological research of the laboratory has been on analysis and forecasting of man's influence on hydrological cycle. For that purpose the laboratory established agrohydrological experimental fields in Siuntio, Lapua and Tyrnävä. Hydrological measurements were also carried out in small forested catchment area located in Siuntio.

The following dissertations made under the supervision on Professor Vakkilainen belong to hydrology:

- Tuomo Karvonen: A model for predicting the effect of drainage on soil moisture, soil temperature and crop yield (1988)
- Matti Ettala: Short rotation tree plantations and hydrological aspects in landfill management (1988)
- Riyadh Al-Soufi: A mathematical model for the watershed hydrologic system (1989)
- Juhani Kettunen: Model oriented data analysis with applications to lake and soil water simulations (1993)
- Auli Niemi: Modeling flow in fractured medium (1994)
- Markku Puupponen: Structural development of the Finnish national hydrometric monitoring network (1998)

Hydrological research has been made also under other professorships of Helsinki University of Technology. Kim Pingoud defended his thesis on infiltration in 1985 under guidance of the professor of system theory. Risto Kuittinen's doctor's thesis on determination of areal snow water equivalent using remote sensing methods under the supervision of professor of photogrammetry was accepted in 1988.

In addition to Helsinki University of Technology, engineering hydrological research has been carried out at University of Oulu and also in smaller scale at Tampere University of Technology.

The first professor of hydraulic engineering at University of Oulu in the years 1961-65 was Dr. Matti Wäre. He supervised Seppo E. Mustonen's dissertation on effects of meteorological and basin characteristics on runoff. Professor Wäre's successors were Kauko Niinivaara in years 1967-72 and Jussi Airaksinen in years 1973-78. The dissertation of professor Airaksinen was accepted in 1971 and dealt with flood routing.

Professor Jussi Hooli moved from Helsinki University of Technology to University of Oulu in 1982. Of the dissertations made under his guidance the one of Veikko

Lammassaari on hydrological effects of timber floating belongs to hydrology. Lammasaari published his thesis in 1990. A special attention in Oulu has been paid to developing suitable methods for water protection in peat production areas. Mauno Rönkkömäki developed hydrological models for this specific purpose and Raimo Ihme analysed the efficiency of the overland flow method for removal of pollutants from peat mining water in 1994.

The dissertation of Pertti Seuna on the hydrology of small research basins was accepted in 1983. The study of Jouko Saarela dealt with infiltration characteristics of different surface structures on landfills in 1997. Both theses were accepted at Tampere University of Technology.

Professor Pentti Kaitera



Pentti Kaitera (1905–1985) received the degree of Master of Science in Civil Engineering with excellent grades in 1929. After the graduation he completed the national military service in a memorable way: he is still the only student of the Reserve Officers School who received highest grades in all subjects.

In 1932 The National Board of Agriculture assigned Kaitera to head research activities in agricultural water management. Doctor Pekka Kokkonen had initiated these activities in 1929. Kaitera's tasks were to investigate methods for dimensioning water channels and assess the impacts of drainage works on catchment hydrology. To accomplish

the goals he established a network of research basins, which was the first network of representative basins in the world. In these basins terrain properties were mapped and precipitation, water equivalent of snow, depth of frozen ground, and runoff were monitored until 1958. In some of the basins groundwater levels were also recorded. In one of the basins hydrological effects of draining bog areas were studied.

Kaitera's first research publication addresses magnitudes of channel roughness length and application of normal distribution in describing the variability of hydrological variables. His most significant hydrological investigations dealt, however, with snowmelt and runoff produced from melting snow. These were the topics of his doctoral dissertation, which came out in 1939. The opponents, professor Hallakorpi and doctor Renqvist, awarded the dissertation with best possible evaluation. Despite of engineering background Kaitera's research approach was typical to the way of reasoning in natural

sciences. He was also actively involved in the experimental part of the research. Error analysis of the experimental data was carried out thoroughly. An important part of the dissertation is discussion of evaporation from a snow surface.

During the Winter War Kaitera took part in the fortification works, where his main interest was organization of anti-tank defense. In summer 1940 he suggested to general Hanell how compressed air could be used to melt the ice cover of lakes. The concept was simple: a network of pipes is laid at the bottom of the lake to inject air into the water. The air stream forces 4 °C water to move towards the surface where it causes the ice cover to melt. Field marshal Mannerheim was excited by the idea, but it was used only little during the war. However, after the war this concept found use in keeping ferry routes and log pools of sawmills free of ice.

In 1942 Kaitera was nominated the professor of agricultural water management at the Helsinki University of Technology. Along with research in hydrology Kaitera had also earned credit in investigations of drainage methods and agricultural engineering in a wider aspect. Due to the Second World War he took the professorship only in autumn 1944. During the Continuation War he acted as the managing director of Suurtalkoot ry and thus participated in arranging food and fuel supply for the nation. At the end of 1942 he became the head of the Evacuation Office, where he was responsible for evacuation of 63 000 Ingrians from the Leningrad area to Finland.

Kaitera's first investigations at the Helsinki University of Technology addressed drainage of cultivated areas. In 1949 he extended the peak flow analysis of his dissertation thesis by incorporating flow data from the main river basins of Finland. This work resulted in a so-called Kaitera's nomogramme, which is a tool for determining the mean-high-flow as a function of catchment area, lake percentage, and water equivalent of snow. This nomogramme is one of the most prominent achievements of hydrological research in Finland.

Starting in the late 1940's Kaitera became more and more aware of the need to promote development in the remote areas, especially in northern Finland. These ideas stemmed from the early years of his academic studies. Research activities received less attention and he started actively to push for the establishment of a university in Oulu. Finally in 1958, the University of Oulu was founded and Kaitera became the first rector. His influence can be seen in the composition of the faculties. On the contrary to the usual European practice, technical sciences were not separated into their own university. Instead, the University of Oulu followed the American model where a faculty for technical sciences resides within the same university along with humanities and natural sciences.

After resigning from the University of Oulu, Kaitera took interest in two issues: tectonical investigations of continental plates, and promotion of emerging development co-operation. He developed a theory of crustal movements based on the hypothesis that chancing pressure in the oceans induces mass flow towards the continents under the crust of the earth. After visiting Africa on several occasions he first had an idea to use development co-operation resources to establish and fund an university in an African

country. Soon he realized this to be unattainable, and instead he organized a MSc-course in water resources for African students at the Helsinki University of Technology in Otaniemi.

In 1968 Kaitera found again more time for hydrological research, and had a lysimeter field built in Otaniemi to study hydrological processes at small scale. The observations for Kaitera's last research project in hydrology were carried out in the lysimeter field. The project dealt again with evaporation from the snow surface and the results, which were published in 1972, confirmed the conclusions presented 33 years earlier in his doctoral dissertation.

After his retirement Kaitera discussed in several publications problems arising from the relations between scientific knowledge and religious faith. It is intriguing to observe that in these studies, too, he applied statistical methods.