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THE TREATMENT AND HANDLING SYSTEMS OF DE/ANTI-ICING CONTAMINANTS WHICH GENERATED AND DISCHARGED INTO SURFACE RUNOFF FROM AIRPORTS TERRITORIES

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Abstract. It is essential to evaluate the fact that our living environment day by day faces with the damage caused by contaminants that are appearing within the surface runoff from airports. Even though, airports are not always being assumed as industrialized components, works, that are being carried out in everyday life in airports, including simple tasks such cleaning or washing vehicles or aircraft, procedures such repair works, fundamentally everything, that takes place on the airport area grounds, still do discharge contaminants into the environment. This sort of activities that are being carried out in everyday life, in fact create severe natural surroundings issues, pollution is not always are being controlled. Therefore, regarding these issues and in order to be able to control them, it is extremely important to observe a degree of contaminants discharged within the environment and to maintain their sorting and adequate processing. An industry as airlines manage numbers of threats and restrictions regarding the area of airline fields, taking into consideration anti-icing and de-icing processes. Regulations of the treatment processes of surface wastewater that are polluted by the drainage approaches in cold weather temperatures are essential for many airports that operate within north climate. The paper summarizes information of certain airports located in foreign countries, techniques and appropriate methods that are used in order to slow down or decrease contaminants that are being discharged within the surface runoff and backwaters. Taking into account international practice this paper introduces proposed surface runoff treatment technology at Vilnius International Airport in Lithuania.

Keywords: *de/anti-icing fluids, handling systems, runoff, treatment.*

Introduction

Each airport, that is located in North climate considers using and applying best technologies to treat the surfaces runoff that are affected by de-icing or anti-icing factors and these are a major subject for all of them. Industrial contaminants within the surfaces in airports procedures are normally de-icing and anti-icing results.

De-icing liquids or fluids can be categorized in two main sections including: De-icing liquids that can be glycol that is heated and diluted by water in order to de - ice and used to get rid of freeze of snow, (in other terms as Newtonian fluid's viscosity remains constant, no matter the amount of shear applied for a constant temperature. These fluids are related with viscosity and reducing stress, as for example: water, alcohol, gasoline). And the other section is anti-icing liquid (undiluted propylene glycol based fluids) or non - Newtonian fluids, (non-Newtonian owing to their characteristic viscous flow). Fluids that are thickened as for example, half-set gelatine, and can be used in order to reduce of ice, snow, sleet, and stop them from accumulating on the surface.

Even though these methods help to reduce the effect of frost, sleet or icing, these components emit numerous levels of oxygen into waterways. Pollution issues that arise as the result of glycols, urea along with additional de-icing, anti-icing liquids. According to Valarezo *et. al.* (1993), depleted oxygen levels can threaten aquatic life, whereas the ammonia by-product of urea is toxic to aquatic organisms. Even though, glycol-based de-icers are considered as used a lot less for pavements de-icing, but urea is still greatly used among biggest airports in continents as Europe or North America. And North climate airports use acetate/formate based runway de-icers.

With the appearance of regulations concerning aircraft de-icing and management of spent aircraft de-icing fluids (ADFs), many airports now face the dual challenges of simultaneously maintaining public safety and protecting the environment and are challenged with multiple constraints when it comes to airfield pavement de/anti-icing (Switzenbaum *et al.*, 2001; Sulej *et al*., 2012). Taking into account, that the majority object is the safety regulations of airlines and their aircraft, therefore enormous supplies of de-icing, anti-icing substations (pavement de/anti-icing products PDP) are necessary to ensure safety and mobility. Airports, that operate in winter conditions must ensure the highest safety for the passengers, crew and everyone around the airport area, therefore numerous quantities of propylene glycol and ethylene glycol-based products are used to remove ice from runways and paths.

It is essential to be a good judge of technology used for de-icing procedure, that operate within the area of the airports, this is necessary in order to prevent accidents and obstacles related with the usage of de-icers that consists of chemicals. In addition, these mechanisms often have important implications for the development of an airports de-icing management plan and the selection and operation of appropriate deicer treatment technologies. The transport and fate of spent de-icers is site specific and connect with environmental conditions, operational activities, regulations and airport infrastructure.

Assessment of environmental risks requires that the procedures of de-icers application, dispersion and transportation across airports territories is of crucial importance. As scientists (Ferguson *et. al.*, 2009; Shi *et al.*, 2017) have pointed out, airports authorities' approach to de-icing handling strategy selection should be site specific because appropriate decision will depend on a particular environment, airport infrastructure and operational procedures and policies. Therefore, it is essential that available de-icing and anti-icing techniques and methods, along with the subsequent de-icing waste management technologies, should be properly studied for a well-informed decision making.

Research Subject and Methodology

While conducting research for this project work, variety of different sort of factors were used: namely, specialized publications (books, paperwork's, etc.), industries and scientific periodic publications (journals, communiques, etc.) and electronic publications (expert blogs, airports and government web-sites, references). Other additional information, that can be useful to determine certain kind terms of PDPs that were used at Vilnius and other countries airports, were collected together having personal and telephone consultations with airport operational employees, such managers, consultants, de-icing agents manufacturers, industry's associates, aviation regulators and others who could be beneficial in order to conduct the most of this research. Even though, some specialized research means such as Science Direct were applied to obtained additional approach. Lastly, rather modest amount of information was received from academic peer-reviewed literature's subjects.

Few years ago, a new project for Vilnius airport (VNO) was proposed to be carried out. The project with a name of "Airport Surface Runoff Treatment Plans". The announced plan was a result of intermediary coordination and utilized variety of expertise, including, but not limited to, evaluation of the airport's infrastructure and topography, engineering-geological studies and so on

Treatment systems

There are three main categories of the treatment and disposal of de-icing and anti-icing runoffs schemes in existence: off-site, on-site, and recovery. The off-site layout gathers of de-icing wastage and its subsequent transfer to a treatment and disposal facility. This process can be done by channeling de-icing runoffs through the particularly designed sewer networks to an available wastewater treatment plant. The second on-site scheme assumes that aerobic and/or anaerobic treatment facilities are available on site of an airport. In other words, the airport has built an infrastructure for treatment and disposal of its own de-icing and anti-icing waste. There are several sorts of particular implementation of this structure, such as soil treatment systems, aircraft de-icing pads and wetlands systems. The last recovery scheme is a kind of on-site scheme's variation, but with a significant difference. The recovery scheme also requires that needed infrastructure for handling and treatment of de-icing waste was built on-site, but instead of disposal of waste, the scheme supposes recovery of still useful active ingredients such as glycol from de-icing waste. Recovery is achieved through runoffs filtration, reverse osmosis, and subsequent distillation. However, recovery scheme is only viable when glycol concentrations in de-icing waste is greater than 5 %. The recovered glycol is reprocessed and sold for use in non-aircraft applications. Usually recovered active compounds are sold to the buyers outside of aircraft industry. Below are described some of the possible treatment systems alternatives of the second scheme.

Soil treatment systems

Factor that is known widely, and that most of the airports have great areas of land available to them. The available lands resource makes soil treatment systems as one of the most attractive alternatives for de-icing waste managing and disposal. In addition, the cause for that is that technology of soil wastewater disposal has been very well-examined and its applications has produced scientifically proven desired effects. Between all the others McGahey and Bouwer (1992), Klecka *et al.* (1993), Castro *et al.* (2001) and others studies have shown that glycols degrade in soil pretty considerably. Scientific exams in simulated environments have shown huge range of ethylene glycol's bio-degradation. Microorganisms naturally exist in the soil and the groundwater bio-degrade ethylene glycol less than during three days in most cases. Zurich airport in Switzerland is one of the most noted examples of prosperous implementation of soil treatment system to manage de-icing wastage.

Aircraft de-icing pads

Most aircraft de-icing and anti-icing works are applied at the passenger terminals and aircraft parking ramps. As a result of this, snow accumulated from these places is usually polluted with the aircraft de-icing fluids and its chemicals (ADFs), the same as with the pavement de-icing products (PDPs). In order to manage and solve this issue the particular aircraft de-icing pads were created. These pads collect polluted wastewater generated during aircraft de-icing and anti-icing procedures. Different sort of materials is available to use for this pads, but normally concrete, reinforced rubber or polypropylene mats are in use. Sometimes inflatable air or foam berms are deployed to collect polluted wastewater runoff. For instance, at Albany International Airport (ALB) in USA there are two concrete pads. Every one of it has a different its very own seepage/drainage accumulation framework, which store snow contaminated with de/anti-icing chemicals. The snow that at long last melts down follows to the drains and then it flows into the airport's liquid waste storage units. As an alternative to permanent structures are the temporary pads which can be less expensive and mobile. Hence, they can be deployed when and where they are needed, for example near taxiways and close to departure runways. The temporary de-icing pads are made from thick rubber mats that are grooved and reinforced with steel cables. These kinds of mats are expected withstand extreme span of temperatures, ranging from -50 °C to 50 C. The grooves' purpose is to channel wastewater to existing drainage systems: open trenches or trench drains that are located at the sides of the mat. The mat can be placed on an asphalt or concrete taxiway and can be moved if necessary. Copenhagen International Airport boasts the biggest rubber mat that is presently in use in Denmark. The mat is situated near the airport's departure runways. The system was mounted in 1992 and concludes of the following: the rubber mat, a drainage accumulation system, and wastewater storage tanks. Barash *et al.* (2000) has mentioned that the system is able to collect together up to three fourths of applied aircraft de-icing fluid.

Wetland systems

Researchers (Kadlec, Wallace, 2009; Vymazal, 2014; Freeman, 2016; Wang, *et al.*, 2017) give description of wetland treatment systems as engineered systems that utilize natural processes to clean out a variety of contaminants from surface runoff in a controlled subsurface environment. Afterwards purified wastewater is either discharged into receiving waters. However, presently only a few airports around the world utilize full-size wetland systems. Kalama Airport in Sweden was the first airport to officially construct and deploy wetland system for de-icing wastewater processing around 1996. At the present time Kalama Airport in Sweden, Toronto Pearson Airport in Canada, Wilmington Airport in the USA, Westover Air Reserve Base in the USA, Edmonton Airport in Canada, Heathrow Airport in the UK and Buffalo Niagara Airport, USA employ this system. Among advantages of wetland systems scientists (Kadlec, Wallace, 2009) list operational simplicity, low implementation, operation and maintenance costs, construction from locally sourced materials and, most importantly, that in such a system no residual sludge is produced. Important thing is that as additional benefits of such systems that they operated in a subsurface level and, hence, the risk to airfield operations is minimal less (Wallace, Liner, 2011). Another important benefit is that no water surface is exposed during treatment. This serves to minimize energy loss through evaporation and convection, provide insulation for microbial communities, reduce wildlife attraction (where this is undesirable, such as at airports) and reduce hydraulic failures caused by ice formation (Kadlec, Wallace, 2009; Wu *et al.* 2015). These features qualify wetlands systems with flow hidden under ground the best choice for airports that operate in the northern latitudes where the temperatures are usually low all year round.

Glycol Recycling

Most of the wastewater treatment plants (WWTP) either refuse to accept ADF polluted wastewater from airports or, if they accepted, then wastewater reception is quite expensive. The reason for that is that glycol-based ADFs demand significant oxygen quantities. To deal with this problem and at the same time meet environmental regulations, few European and North American airports (i.e. Denver International Airport in USA, Bradley International Airport in USA, Minneapolis-St. Paul International Airport in USA, Munich Airport in Germany, the Oslo Airport in Norway and the Lulea Airport in Sweden) now retrieved glycol from ADFs polluted effluent. Additional benefit of glycol retrieval is that airports can sell the recovered glycol and, therefore, can cover some of their expenses for treatment of runoff. Retrieval happens by applying usual separation methods of removing water, various solid fractions and, occasionally, corrosion inhibitors and various other additives from polluted runoff. The glycol recovery and recycling processes usually include several stages, such as simple filtration and Nano filtration, ion exchange and reverse osmosis, evaporation and distillation. Usual goal of system's design is to gather runoff from aircraft de-icing and anti-icing operations in such a way as to reach maximum levels of glycol concentration in surface water runoff. Then airports are able to sell most of the so retrieved glycol to chemical manufacturers, which can use it for production of different glycol-based products (Barash *et al.*, 2000).

Airports polluted runoff treatment and handling schemes

Munich Airport, Germany (MUC)

Like the majority of airports in Munich airport use de-icing chemicals in cold temperatures to get rid of ice and snow from aircraft before them taking off. Afterwards polluted wastewater travels through a system of drainage gutters and channels into underground reservoirs specifically designed to hold it. Next, the airport mechanically and chemically treats wastewater. Distillation happens at the specially built airport's wastewater treatment plant where finally original de-icing properties returned to collected runoff through addition of necessary chemicals. Munich Airport's example is unique because it is the only airport in the world that recycles de-icer. Most of the other airports simply recover to sell, but do not recycle glycol. Munich Airport gathers and holds wastewater in two concrete subsurface reservoirs. The first reservoir has 73000 m^3 capacity. The second one has 95500 m^3 capacity and it is fitted with lined detention. The airport discharges surplus wastewater, which exceeds ADFs recycling needs, to a local wastewater treatment plant. Differently from other most of airports, Munich Airport has a peculiar constructed bio-degradation system that collects and treats polluted runoff from the airport's taxiways. It is introduced 30 cm beneath the runway surface. At the base of the framework lays a slight 1mm layer of bentonite powder. It is encased inside two layers of impenetrable material. According to Barash, *et al.* (2000) the top layer covered with another layer of loosely packed sand. The sand hosts a certain bacterium capable of bio-degrading de-icing and anti-icing contaminants found in aircraft and pavement treatment's runoff. This system is typical for the airports that collect and treat wastewater for the purposes of glycol recycling.

London Heathrow Airport, London (LHR)

The Heathrow airport boasts a multi-stage treatment facility on site. The system's set up aimed to catch maximum levels of high-strength, ADF enriched effluent for subsequent treatment. In addition to the usual runoff coming from the regular cleaning of the airport surface, the system's installation is able to catch runoff from all terminals, runways, and cargo areas. All polluted wastewater transferred via the transit pipeline to a specially designed treatment facility, which is located 2 km south of the airport. According to Richter *et al.* (2004) the process of treatment includes several following stages. First, the polluted wastewater enters the main basin (MR), where primary treatment of aeration begins. The wastewater is treated with a stream of compressed air bubble. After finishing the first stage of aeration wastewater next transferred to the balancing pond (BP), where a secondary treatment of aeration occurs. After that, wastewater again transferred. This time to the subsurface flow (SSF) constructed wetland system. The system covers an estimated total surface area of 2.08 ha and includes a network of twelve wetland cells of various sizes. All cells are filled with gravel of 10 mm sub angular flint to a depth of 60 cm. Cells contains hydraulically discrete compartments. To prevent loss or ingress to the wetland cells, they are lined with an impermeable bentonite liner. Flow rates and water levels in each cell are accurately controlled. Richter *et al.* (2004) notices that the different surface areas of each cell allow to have different inflow rate for each cell. This in turn allows to maintain constant hydraulic loading rate across the system. Each cell has open-water channels at the front and end of the cell. These channels distribute and collect water flowing through the cells. Another water channels encompasses the sub cells. These channels reduce the possibility of short-circuiting along the whole area of the cell (Fig. 1).

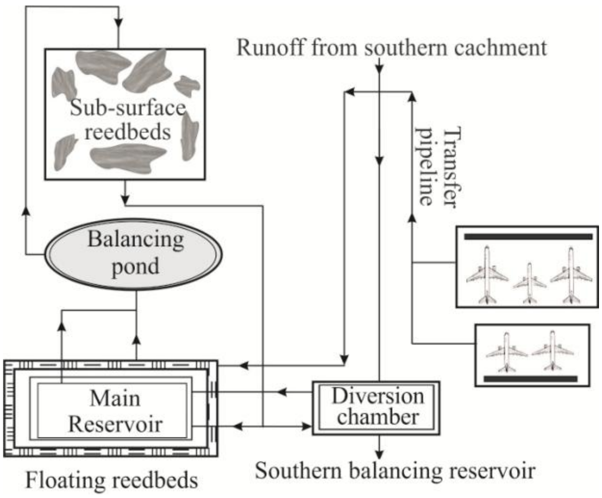

Fig. 1 Simplified drawing of Heathrow airport treatment scheme

Albany International Airport, Albany, NY (ALB)

Albany International Airport's treatment system has two units that apply identical treatment to collected runoff from de-icing and anti-icing operations. Each anaerobic biological treatment unit consists of two liquidized bed biological reactors. Collected wastewater first directed to a lagoon. Then on the facility's personnel discretion the water from the lagoon is pumped either to one or another anaerobic unit for treatment. (Fig. 2).

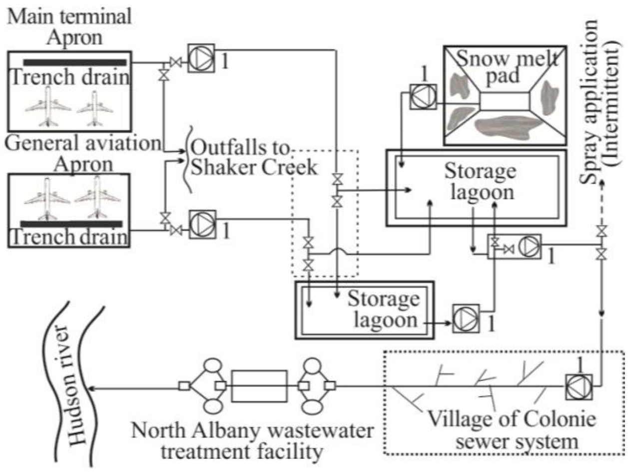

Fig. 2. Simplified drawing of Albany treatment scheme: 1 – pump station

Usually two treatment systems are run in parallel, however, occasionally the airport needs to run them in series. Each unit has 4.3 m in diameter and 10.5 m in height. Each of them is packed with 10 tons of granular activated carbon. Retention basins and storage reservoirs can hold and equalize between them about 50000 m^3 of de-icing surface runoff in total. The treatment systems itself was introduced in 1998. As indicated by the terminal's experts the framework gathers and treats around 70 % of all de/anti-icing compounds utilized in airport terminals activities. The treatment system was built with accordance to the Airport Authority's performance requirements and specifications.

First requirement was that a minimum inflow rate had to be of 450 liters per minute, totaling 141000 m^3 a year. Second requirement was that the system was able to reduce propylene glycol concentration from an average of between 4800 and 7500 mg/l to below the detection limit of 1 mg/l. In addition to that the system was expected to reduce the chemical oxygen demand (COD) by 90% or greater. The system recirculates de-icing surface runoff water through the unit so that influents collected achieve homogeneous most of conditions. After anaerobic treatment application, wastewater is harvested for glycol, which airport subsequently converts into methane gas, carbon dioxide, biomass and, in smaller quantities, propionic acid. Methane production allows the system to self-sustain because methane covers for energy needs for space and process heating. At the end of each unit the airport has an ability to monitor COD concentration levels. Each morning airport personnel collects grab samples from the units to evaluate the treatment performance (Fig. 3).

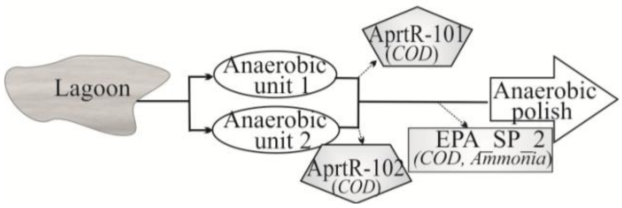

Fig. 3. Simplified drawing of Albany biological treatment system and sample points

Usually wastewater left after glycol recovery is directly discharged into local Shaker creek. However, to be able to do so the airport must meet thorough and strict requirements for the discharge directly into the natural surface water systems. All the rest of effluent is stored either for a subsequent commercial spray irrigation of the airfield or for a transfer wastewater treatment plant during winter season. The system consists as well of special instalments that separate, capture and return carried over bed carbon. In some cases, the airport uses the treated wastewater for irrigation of its airfield in warmer temperatures. Some of the biomass is too fine to be separated and captured; so it is discharged together with effluent used for airfield spray irrigation. Noticeably that Valarezo *et al.* (1993) notices, although the airport has the capability to discharge directly to a wastewater treatment plan, but it rarely or never does so.

Syracuse Hancock International Airport (HIA)

The Syracuse Hancock International Airport (HIA) is a typical medium-sized regional airport situated near the city of Syracuse, state of New York, in the eastern part of the States. The airport manages approximately 150 000 flights and over 20 million passengers yearly. The airport is increasing significantly. For this reason the airport recently led to the construction of new terminal facilities and an advanced de-icing waste management system. Exceptional period in Syracuse Hancock International Airport is the period of October to April then the airport gets on average of 534 mm of precipitation coming in the form of sleet, freezing rain or snow. As a result of this numbers of precipitations quantity de-icing fluids used in airport is relatively high in relation to its air traffic. Normally during the period of the year, the airlines operating in the airport use up on average 727 m^3 of concentrated aircraft de-icing fluids. All these fluids are propylene-glycol based. The airports de-icing waste management facilities includes three centralized or remote de-icing pads together with collection facilities, one special snow melting pad for polluted snow, three open storage and treatment basins, and concentrate storage reservoir (Everett *et al.*, 1997). When surface runoff is collected from the central pads, it is transferred through pump stations and power mains to the repositories, which are situated which are situated near by the area of the airport. Before transfer an in-line total organic carbon (TOC) analyzer is employed to detect glycol concentrations. Dependent on concentration levels wastewater diverted to an appropriate reservoir: fluids with material over 15 % glycol go to the concentrate storage reservoir, material with less than 15 % glycol transferred directed to the basins. Figure 4 schematically illustrates the system.

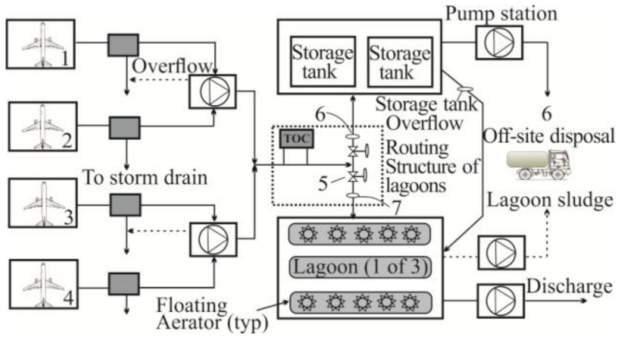

Fig. 4. Simplified drawing of Syracuse Hancock international airport treatment scheme: 1 – north collection pad; 2 – snow melt pad; 3 – south collection pad; 4 – west collection pad; 5 – control valve; 6 – concentrate; 7 – dilute waste

Usually HIA carries its treatment and disposal of glycol wastes during summer months. In three open storage basins there are collected wastewater where his added to the nutrients and buffer supplemented, then microorganisms are added, and lastly floating high - speed mechanical aerators enrich wastewater with oxygen. The aerators are turned off only after the waste BOD_5 is reduced to less than 20 mg/l. After that time is provided for biosolids settle down. Those residual biosolids are eventually gathered from the bottom of the basins and transported to the county's treatment plant for final treatment and disposal. The remaining liquid mass is released directly into local natural water system disposal (Valarezo *et al.*, 1993).

Vilnius International Airport (VNO)

Taking the newest technologies into consideration that could be used as airport surface water treatment, the pre-project solutions were prepared. In cold season Vilnius airport uses de-icing and anti-icing materials to purify both the aircraft and its runways. In summer season surface runoff and wastewater from the bigger part of the airport area and its surroundings (as namely, southern, central and eastern territories) flows into Rudaminele river. Nowadays, carbamide is still used in Vilnius airport significantly. Unfortunately, the base of this compound contains nitrogen and its compounds. Consequently, when carbamide enters into water systems surrounding the airport, surface water, reservoirs and systems get polluted with ammonia. In the course of natural cleaning conditions, it is difficult to eliminate or get rid of this compound. Moreover, this substance is very harmful on the asphalt: to reach the similar impact increasingly more carbamide can be greatly required. As a result of this, airport authorities intend to switch from urea to acetate and formate based products. Additionally, authorities announced planned expansion of the airport territory to accommodate for a construction of surface runoff treatment plant. Along with this and other intended infrastructure total area of impermeable pavement will reach the size of about 50 ha.

The frame of Vilnius airport's established runways, placement of other infrastructure and current traffic load makes it virtually impossible to construct new de-icing and anti-acing pads. In order to do that its airport territory was divided into 5 project zones (Fig. 5).

Currently, all polluted wastewater whit de-icing and anti-icing fluids residues reaches simply local sewers systems collecting network. The project suggests install a new wastewater network system and to isolate the existing one. The reason for that is that the flow of polluted runoff, accumulated during the winter season could be separated and transferred to certain location in the part located in the South of the airport area. This pre-project is situated to design and install of the following objects: three subsurface runoff pump point with build-in pumping system as in the example of (Ps1, Ps2, Ps3), one runoff pump point with pipes located above the ground (as per Ps5), two organic substance sensor indicators (TOC), one two-section buffer reservoir, runoff irrigation system and gravity precipitation network. Four oil and sand separators will filter out oil and sand from collected runoff. According to the design winter runoff is directed under pressure through a newly planned pipe. At the beginning of this pipe an overflow well is located. The well with have a knife gate valve and electrified gear stops summer runoff from entering the common system. Additionally, an oil-sand separator is installed behind the knife gate valve. The gravity and pressure networks direct collected runoff from the northern part of the airport to the southern part. In the northern part of the airport winter runoff is isolated by knife gate valves with electrified gears. This runoff goes to the TOC sensor-equipped well. This sensor will help to distribute polluted runoff through electrified valves. The runoff (according to runoff contamination) will be passing either to the existing gravity precipitation runoff network or to a new pump station Ps1. The Runoff from the eastern and western parts of the airport is collected with a help of now existing precipitation runoff networks. Here overflow wells separate winter runoff. Another knife gate valve with electrified gear allows to disconnect winter pipeline when it is necessary. Similarly, to the northern part's set up, an oil-sand separator installed behind the overflow well and the knife gate valve. Here flow is distributed, and control samples are taken. After the separation of oil and sand runoff is directed into the pump point of Ps2. From there runoff pumped into the existing precipitation network. This process has to be managed by sump pump station and looked after by hydrostatic level meter. On the existing line is equipped with an oil sand separator that can work with the summer rainwater runoff.

The sump of the main pump station Ps3 in the southern part of the airport collects all winter runoff through the existing and newly designed networks. Organic substance sensor sorts the collected runoff according to their contamination rate. TOC sensor manages the activity of electrified valves and distributes runoff as depending on the level of pollution range. Very concentrated surface runoff gets into the system of networks initially. At first this runoff is diverged for keeping into the smaller part of the reservoir. Next from there it is transferred to a wastewater treatment plant. In case of the rain or the melting of the ice, runoff is diluted and ought to be redirected to the next part of the tank where not very contaminated runoff is accumulated.

If snow melting or rain is particularly intense, runoff dilutes even more. Its pollution is approaching the level of pollution at which it is allowed to discharge wastewater directly to natural surface water basins and systems. However, occasionally the pump can't handle too high yield. If this case happens, that the sump of the pump station Ps3 gets overfilled and surface runoff goes directly to the precipitation runoff network and eventually gets to the common precipitation water collector. In case of large quantities of precipitation, the contamination of runoff will be rather insignificant because of dilution. Consequently, such situation will have little effect on the general state of runoff contamination.

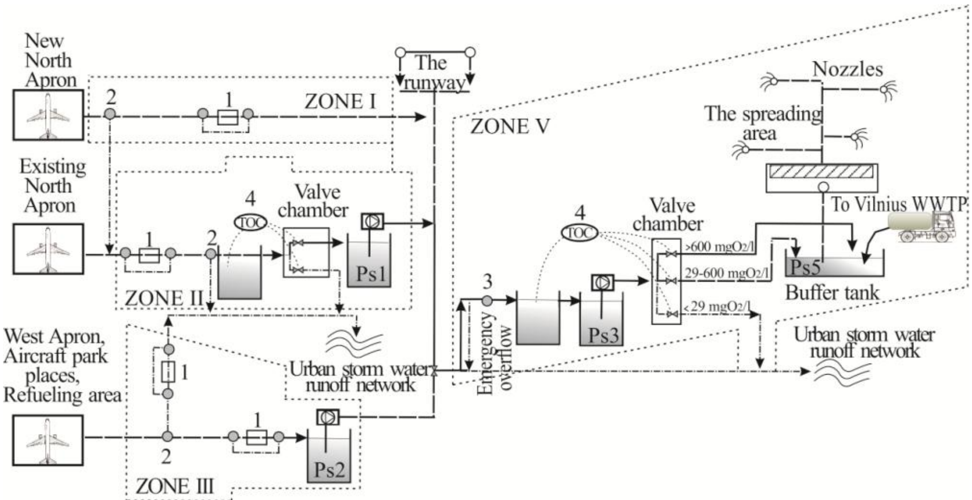

Fig. 5. Simplified scheme of Vilnius airport treatment system: 1 – oil separator, 2 – switching between summer or winter, 3 – switching for the winter period, 4 – organic materials probe

The buffer reservoir has hydrostatic pressure-measuring device installed. It's used for reservoir water level control. In the case then water level hits the allowed maximum water level in the buffer reservoir, the pump station Ps3 gets disconnected and stops delivering surface runoff into the reservoir. If amount of water is lower than the allowed operating level, the pump station Ps5 gets disconnected. The intention here is that the collected runoff, if possible, should be kept in the reservoirs until the warmer season comes. During warmer period weather conditions allow for a much quicker bio-degradation process in soil to take place. This should be set during the operation of the equipment. The runoff gradually filters through the various cleaning layers of grounds. Contaminants get dissolved and disposed in the result of various processes and reactions of physical, chemical and biochemical nature. The system equipped at the Zurich airport provides a good example is the irrigation with surface runoff. According to the conducted research the highest efficiency of potassium acetate runoff treatment is achieved 20 to 30 cm below soil surface.

In this layer of soil microorganisms manage to purify surface runoff from 80 to 90%. However, to protect the underground waters from pollution, runoff needs to be purified completely. In the aforementioned Zurich airport system, a full cleaning (100%) layer is about 80 cm. If the groundwater is high, such a system should be maintained and controlled. The irrigation system needs to be shut down, when water level rises higher than 80 cm.

Invariably a certain quantity of sludge, sand and another residue will appear at the bottom of the reservoir. It will be necessary to remove this residue regularly and dispose of it at one of the city's wastewater treatment plants (WWTP).

Conclusions

There are two basic categories of de/anti-icing fluids: de-icing fluid for snow/frost removal, and anti-icing fluid applied to prevent snow or sleet accumulation on a road of airport.

The pollution determined by the airport's runoff appears when rain is transporting atmospheric sediments and used chemicals from the airport area. This can be a great deal of inconvenience, especially if there are no wastewater treatment plants at the airport and the existing wastewater treatment plant is not functioning properly. There are few systems for the treatment and disposal of de/anti-icing runoff. These three main categories of used systems to solve these concerns are off-site, onsite, and recovery systems. The off-site frameworks are normally based on gathering of contaminated airports surface runoff and its transfer to an outside wastewater treatment plant for its treatment and disposal. The on-site systems are intended to resolve the concern by creating necessary infrastructure for contaminated wastewater treatment and disposal in airports areas. The on-site systems can utilize different advancements, such as aerobic and/or anaerobic treatment installations or soil-based structures. The third category of recovery systems focuses mostly on recycling the majority of polluted wastewater by simply purifying it, distilling and adding needed chemicals to be able to clean it, and by doing this, it then can be sold to the third parties.

In order to ensure efficient wastewater treatment and the efficiency of cleaning systems, the operation of these systems must be optimized, taking into account the performance of each airport and the quality of the wastewater in them. What de/anti-icing treatment systems to install is decided by the airport directorate whit consulting engineers, after evaluating and adapting the technology to local weather, geology conditions, topography.

To determine which technology is more efficient, one cannot compare them, because each airport is subject to different technologies, depending on airport layout, loads, airplane service technology, topology, topography, climatic and ecological conditions and the environmental legislation in force in that country.

Lithuanian main airport uses de/anti-icing products in winter. Surface runoff with de/anti-icing product residues enters sewage collection networks. According to the submitted project it is planned to build a new surface wastewater treatment system, to install new or renovated existing wastewater networks. To ensure that the planned treatment will be operating at the maximum level of effectiveness the following plans can be implemented to equip new wastewater networks and to isolate the existing network so that the flow of polluted runoff accumulated in winter would be directed to the southern part of the airport and be treated there. In order for the wastewater treatment to run smoothly and the wastewater treatment system to work efficiently, it is proposed the following constructions can be designed: as three under the ground and one above ground runoff pump points, two organic substance sensors, one two-section buffer tank, runoff irrigation system, gravity and pressure storm water reds, four oil and sand separators is highly recommended.

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