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WASTEWATER TREATMENT MODEL IN WASHING STATIONS FOR VEHICLES TRANSPORTING DANGEROUS GOODS

ABSTRACT

Car washing is a task performed by every passenger car owner more or less frequently, mainly to achieve a finer appearance of the vehicle rather than for the need for cleanness.

In the transport business, the owner's concern is to present clean and orderly vehicles on the road as a relevant external element of order, implying good corporate image to customers. On the other hand, in dangerous goods transportation there are other reasons requiring special technology of washing, applicable to the transport means used, depending on the change of type of goods in carriage, the preliminary preparation of a vehicle to load the cargo, or to undergo maintenance.

Water applied in the technology of washing collects the residue of goods carried in the vehicle and is polluted to such an extent that it cannot be discharged into sewers - nor directly into a watercourse - without previous treatment.

The paper presents a solution model and a sequence of technological procedures involved in an efficient treatment of the polluted wastewater in tank wash stations, in which mostly vehicles carrying ADR goods are washed.

KEY WORDS

cleaning, washing, polluted water, treatment plant, neutralization, dangerous goods carriage/ transport.

1. INTRODUCTION

The level of development of traffic typically reflects a highly developed society, along with the development stage of industry in general. Novelties in the area of technologies in industry continually affect the development of traffic and vehicles, resulting in new technologies that further lead to improvements of the means and routes of transport – that is, in transport systems in general.

Unquestionably, dangerous goods transportation is gaining importance in the road transport sub-system that has been recently subject to great novelties in technology, safety and environmental issues; furthermore, this trend is intensified in the segment of ADR transportation by road.

Safety in ADR transport is not only restricted to the traffic situation on roads in the course of carriage, but also in the preparatory stage of transportation, which includes the washing of tanker vehicles – both external and internal.

Wastewater produced in the washing facilities is a major pollution threat to the environment. The water protection legislation is rather strict and prescribes the maximum admissible pollution levels in sewer exhausts and exhausts leading directly into watercourses. Compliance with these legal requirements imposes high financial and technical burden, as well as technological demands, on any entity involved in this business.

2. TANK WASH STATION

A tank wash station furnished with an integral ecological solution for the washing procedures is by no means comparable to car wash facilities for conventional trucks and buses. The washing procedure of vehicles in a modern tank wash station, as well as the wastewater treatment, involves three separate technologies that complement each other and are closely related, applied in the following sequence:

1. technology of vehicle and tank washing,
2. technology of wastewater treatment, comprising:
   - chemical pre-cleaning technology,
   - biological treatment technology.
3. technology of waste sludge neutralization.

2.1. Tank wash technology

Tank wash technology is tailored to the type of cleaning to be done, in particular to the properties of the substance to be removed. In such a division of work, the washing procedure is considered with regard to the purpose, as follows:

- external wash (to improve the appearance),
- internal wash of tanker vehicles, in order to load a different cargo,
- cleaning for safety requirements as required by the resp. technology of maintenance.

Types of cleaning are preset; we need to view those variables that exert the greatest impact on the effect of cleanness. The term 'vehicle washing' must not mislead us to think of the car wash procedure as we know it at home, when we apply water and sponge only. Such approach would simply not do in mass industrial cleaning – it would involve time-consuming manual work and would produce inadequate result. The result of cleanness of all surfaces treated in the procedure depends on five elements that are underlying for achieving the desired outcome of cleaning:

- water pressure,
- water temperature,
- time spent on cleaning,
- washing agent - detergent,
- quantity of water.

In no case can the maximum cleanness be achieved by employing one element only: it always involves a combination of all the five elements. Underlying for achieving the optimum mutual effects are the experience and known technical parameters of the cleaning equipment installed. Therefore, each washing facility develops an optimum set of combinations to be applied in treating different substances.

The parameter of temperature deserves more detailed attention. It has an extremely relevant impact on the outcome of cleaning and the price of the cleaning equipment. In heating the water at the pump intake there are restrictions due to physical characteristics of the medium and construction features of pumps. It may lead to the gasification of fluid, which may stop the flow or even cause the cavitation damage on the vital parts of pumps. If water is heated on the pressure side, with pressures exceeding 100 bar, extremely expensive heat exchangers are required.

2.1.1. External washing

External vehicle washing (to improve the appearance) is the least demanding procedure in terms of technology, as it only washes away the dirt accumulated on the vehicle while driving on the road. On the other hand, the external parts of the vehicle are not equally exposed to pollution, and dirt cannot penetrate into all parts due to vehicle construction: external washing is therefore divided into

- washing the superstructure and driver's cab, and
- washing the chassis.

External washing procedures on vehicles, depending on their purpose, differ in the technology and equipment used. Buses, tarpaulin-covered trucks, refrigerating/conditioned trucks and similar vehicles are washed by rotating brushes. In such cases there is no need for high pressure jets, as the dirt is removed mechanically by the brush. Water is added in the function of final rinsing. The pressurized installation of water and detergent feeding is designed accordingly.

In external washing of vehicles carrying dangerous goods (tankers mostly), rotating brushes are normally not applied, due to the shape and construction of vehicles. The rounded shape of tanks makes it impossible for brushes to reach the entire external surface. Therefore, the technology and equipment applied in external wash need to be adjusted to the shape and model of the tanks. Instead of brushes, there is a framework (gantry) with high-pressure nozzles moving along the vehicle. Adequate pressure to achieve the desired effect – washing the tanks – exceeds 100 bars. The technology of external wash of the superstructure and driver's cab comprises several stages, as follows:

- pre-wash,
- application of detergent,
- washing (high-pressure nozzles, brushing),
- Rinsing.

The solution how to perform external wash for all kinds of vehicles on one wash track efficiently lies in the selection of proper equipment. The main part is the transport bridge moving on guides along the vehicle, in combination with high-pressure nozzles and brushes.

External wash also includes the under-chassis wash. The easiest way to wash the chassis is when vehicles enter the wash track. While entering, the vehicle passes across a shaft where a bunch of high-pressure nozzles are installed and wash the chassis from bottom upwards. To achieve a better effect, in particular in remote and inaccessible places, the manual rinse procedure by high-pressure guns is applied.

The water for the first two stages of external wash (pre-wash and wash stage) can be taken from the re-circulating system, while in the last stage (rinsing) only clean water is used. A plant of this kind requires a carefully designed network with a collector of wastewater from the previous wash procedures, pumped and used at a specified stage of washing. It is obvious that such a technical solution with re-circulating and pumping cycle considerably increases the investment in the tank-washing station. On the other hand, the consumption of water is much lower.

2.1.2. Internal wash of tanker vehicles to load a different cargo

Chemical industry produces new dangerous substances that are brought to the consumer by road in most cases, in tank superstructures. There is a wide

range of cargoes that are perishable and can be easily affected if mixed with the residues of previous cargo. Therefore, internal washing of the tank is indispensable before new cargo is loaded. The main element in internal washing is inserting special rotating heads through the main openings on top of the tank. Considering the size and construction type (the number of compartments) of the tank, each of them can be washed simultaneously if several rotating heads are applied.

Washing heads for internal washing of tanks of older design were constructed so that the energy of the water jet was driving the rotating part. More recent types are more robust and have an autonomous drive rotating the nozzles inside. There are no jet energy losses and the effects of washing are much better.

The technology of washing consists of several stages that follow in this sequence:

- discharge of the residues of the chemical substance,
- pre-wash by water,
- washing applying a detergent,
- rinsing.

In particular groups of related cargoes, the quantity of water, type of detergent and time spent on washing is determined by experience. The quantity of water used in internal wash of tanks is approximately 600 litres per compartment. Accordingly, water consumption in a three-compartment tank is between 1700 and 2100 litres.

The technology applied in internal wash sometimes includes steam, which emits heat and by evaporation heats the interior of a tank very fast. It is suitable for heating the substances that liquefy at higher temperatures and are washed out more effectively.

Steam is also a simple, but very effective way of drying the interior of a tank. The need to dry the interior results from specific requirements of the cargo to be loaded, which does not allow any water in the interior or mixing with water.

In case of very strict requirements for a dry interior of tanks, a worker gets inside a tank and dries it manually, with cloths. Due to these requirements for dry surface, modern washing facilities are equipped with blowers that blow heated air into the tank. This technology is much more efficient and greatly reduces the time needed for drying.

Each carrier finds it extremely important that the truck wash issues the certificate of cleanness after the washing procedure, which is a proof of the tanker's suitable operating condition to load new cargo.

2.1.3. Washing for safety requirements imposed by the maintenance technology

The construction of vehicles carrying dangerous goods is very complex in terms of technical equipment and maintenance requirements. They demand a very professional and systematic approach to maintenance. An empty tanker that had previously carried dangerous goods (inflammable liquid) is even more exposed to explosion risk than a full tanker. In maintenance operations involving the risk of spark or open fire, the tanker needs to be degasified first. Similarly, a carrier has to ensure that maintenance workers do not come in contact with residues of dangerous substances which could affect their health in any way. The wash facilities can achieve the required cleanness and gas-free condition by adequate washing procedure, or by way of blowing the steam into the tank (steaming or degasification), which is often done in practice.

The steaming procedure is rather simple, as the tank only needs to be connected to a steam source. Considering different types of tanks, the steam connecting points can be either through the main opening, or on the discharge installation, on the pressure discharge hoses, on the return feed of the steaming phase, etc.

2.2. Technology of wastewater treatment in truck-wash facilities

As already mentioned, the truck-wash is a necessary activity in the stage of preparing the vehicle for operation – loading a dangerous substance. When a vehicle has been washed, an additional problem arises: how to dispose of the wastewater? It is not easy to answer this question, as the treatment technology of wastewater produced at truck-wash facilities is very demanding.

Defining the dimensions of any treatment facility and technology of treatment in general depends on the type and degree of water pollution. First and foremost, the key problem of treatment lies in the fact how constant the water pollution is in water to be treated. The more the sample of wastewater changes over time at the entry into the treatment plant, the bigger the problems and the lower the probability to achieve the required parameters in the treatment technology applied. It is the technology applied in truck-wash facilities and the changing of cargo, which leaves particular substances in the washing procedure that leads to a very changing character of pollution and the resulting sample of wastewater to be treated.

That makes it very difficult to dimension a treatment plant so as to obtain satisfactory results of wastewater treatment in case of the fast changing input parameters. Similarly, the wastewaters from truck-wash facilities are too polluted to be decontaminated effectively by a single treatment technology to such an extent that water could be suitable for discharge into the sewage system, or even to a watercourse. For this purpose there are two technological procedures for treat-

ment, complementary and very effective if combined. These are:

- technology of chemical pre-treatment,
- technology of biological treatment.

The technology of biological cleaning always follows the chemical pre-cleaning procedure, as microorganisms can improve the parameters of water that has undergone chemical pre-cleaning.

The technology of wastewater treatment is very complex due to the rapidly changing input parameters. In practice, the impact of an inconsistent wastewater sample is eliminated by collecting wastewater in the so-called egalization basin (100-200 cbm). The size of the basin depends on the quantity of wastewater and capacity of the treatment plant.

A suitable immersion mixer is positioned at the bottom of the basin: not only to mix the water, but also to supply air into the resulting turbulent stream. This stage aims to enrich the water with oxygen before the chemical treatment and improve the biological and chemical parameter of water pollution.

2.2.1. Chemical pre-treatment

Chemical pre-treatment of polluted waters is a well-established technological procedure. Treatment plants that were designed for a constant sample of wastewater (processing, food industry, slaughterhouse, etc.) achieve fairly good results. The pollution parameters in the sample of wastewater supplied to the treatment plant do not change, which makes the treatment process simple: the chemicals are dosed constantly, and the construction of the facility is less complex.

As already stated before, it is a much more demanding task to handle the wastewater treatment technology in a truck wash due to its changing input parameters. The chemical pre-treatment actually adds a flocculant that generates floccules, in which the impurities from water aggregate. There are several such substances – organic and inorganic – known, but ferrous chloride $FeCl_3$ proved as the most efficient flocculant in practice.

In removing the impurities from water it is important that the process of combining the floccules into bigger ones be accelerated. This process improves the treatment effect, as bigger floccules segregate from the wastewater much faster. For this purpose, the substance polyelectrolyte is added to the chemical process.

Moreover, the constant pH-value (near the neutral value, pH 7) needs to be maintained in the wastewater chemical pre-treatment process. At neutral values, the pre-treatment process is running at its optimum. The constant pH-value is maintained by adding a base, NaOH.

We need to be aware that the flocculant we use is based on an acid, like some detergents, therefore the appropriate base is used to maintain the neutral condition, which is pre-requisite for an efficient chemical pre-treatment process.

The floccules of impurities that rise on the surface (flotation) and those that sink (sedimentation) are the product of treatment plant (sludge) that requires special processing: the technology of sludge neutralization, or physical secretion of water from sludge. Both procedures will be presented later on.

Chemical pre-treatment of wastewater is performed with two types of treatment plants. The basic chemical procedure is the same in both of them. They differ in the method of supplying the chemicals, technological equipment, construction of the plant, and processing of the sample in terms of time. There are:

- treatment plant with charge processing,
- treatment plant with continuing operation.

2.2.1.1. Treatment plant with charge processing

This plant pumps a certain quantity of wastewater from the egalization basin, which is then treated by adding chemical substances according to the chemical pre-treatment technology. The basin in which the treatment is effected has a special mixer that mixes all chemical substances.

Chemical substances can be added as long as the desired effect is achieved, and there is no danger that untreated water could reach the exhaust. After the treatment, the mixture stabilizes and the floating floccules are taken off from the surface by a scraper. The floccules that sink on the bottom (sludge) are likewise removed and sent to neutralization. The remaining water is left to clear up and then re-pumped to further biological treatment, or to sewage system respectively. The procedure is repeated with a new charge – quantity of wastewater, and the procedure is named after it, a charge processing treatment.

A drawback of this treatment is the requirement for big earthen work for underground reservoirs in which the chemical process takes place. The plant is stationary and cannot be moved. It also requires a great deal more physical work by the operators.

2.2.1.2. Treatment plant with continuing operation

This plant differs from the preceding one in the method of operation. As the name reveals, the treatment process proceeds continually. The technology has developed from charge processing treatment plants, applying new achievements of technology in the field of process control.

In fact, both technologies use a proven method of adding chemical substances (flocculant, polyelectrolyte, constant pH) that enables segregation of impurities gathered in bigger floccules. The most relevant pre-condition to achieve good results of treatment is

to maintain constant pH value – in the neutral range. If this value fluctuates, the pre-treatment process in the plant is held back immediately.

The mixing of flocculant and polyelectrolyte takes place in specially constructed tubes, in a strongly turbulent stream.

The flotation itself, the separation of floating floccules and the sedimentation – the precipitation of the floccules is achieved in specially designed vessels. The separation process is enhanced by the insertion of lamella filters, with lamellas at the angle of 60°, as most convenient for the separation of floating particles. The floccules afloat are taken off by a scraper. The substance that precipitates is pumped out into the sludge collector, jointly with the skimmed material.

The treatment of polluted water in this kind of treatment plant is on a technologically higher level, involving more complex know-how and automation. The key advantage is the reduced dimensions compared with the preceding plant, and its mobility and applicability in any other place, requiring considerably less building work. The drawback is the carefully monitored process, as any fluctuation in pH value leads to the destruction of the process and consequently inefficient treatment.

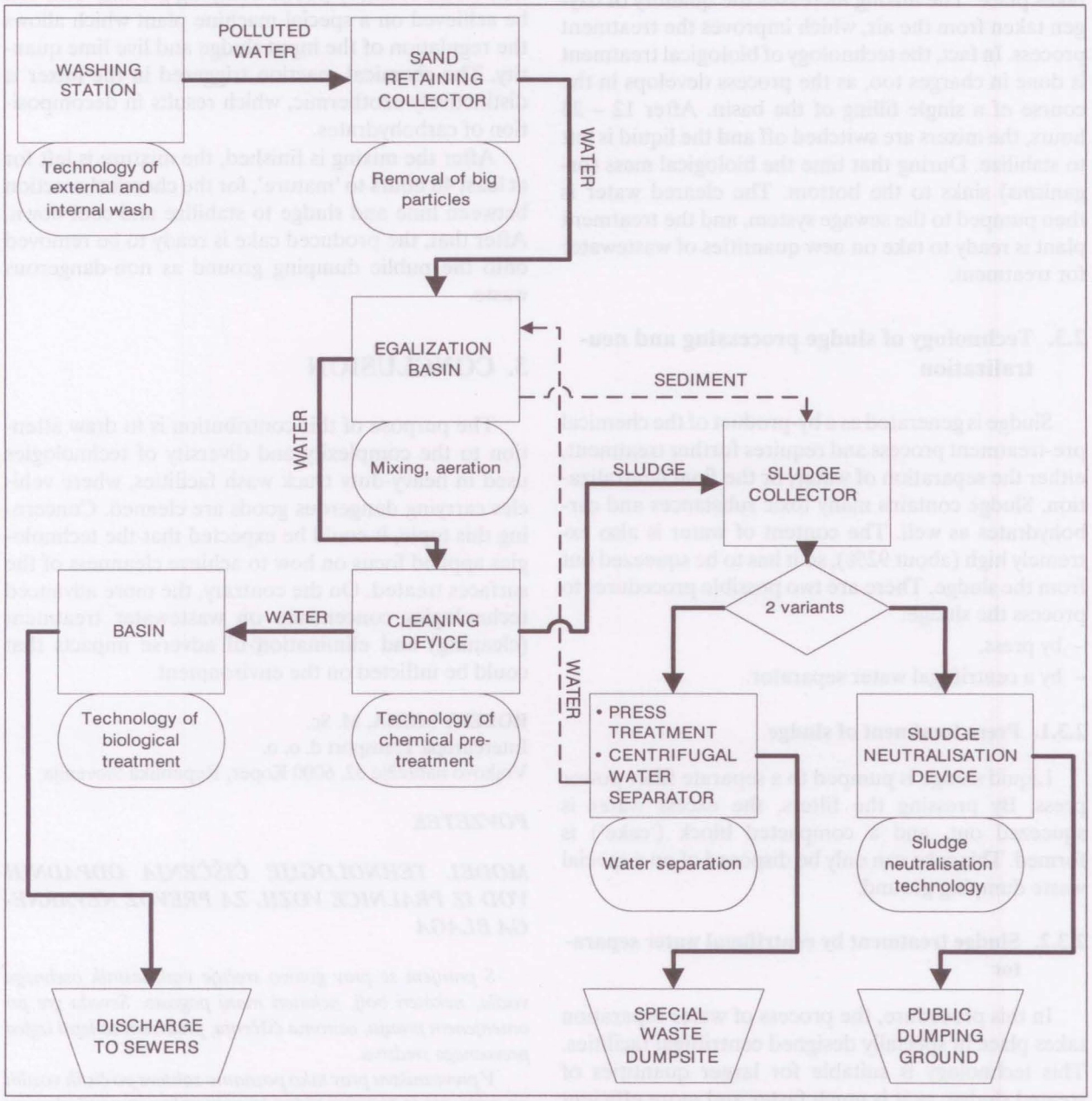

Figure 1 - Diagram showing the Technology Model for wastewater treatment in tank washing stations where vehicles employed in dangerous goods transport are washed

2.2.2. Biological treatment technology

This technology that follows chemical pre-treatment is in fact the final treatment of wastewater by microorganisms, multiplied in a special basin. The input parameters of treated water must be strictly held within the limits set. If they get out of control and change, they may destroy the microorganisms and stop the process of biological treatment. Organisms cannot be regenerated in a short time, therefore the treatment process will be sustained until the live mass is revived.

There are special aerators to mix the water and organisms in the basin, in which the biological treatment takes place. The mixing increases the quantity of oxygen taken from the air, which improves the treatment process. In fact, the technology of biological treatment is done in charges too, as the process develops in the course of a single filling of the basin. After 12 – 24 hours, the mixers are switched off and the liquid is left to stabilize. During that time the biological mass (organisms) sinks to the bottom. The cleared water is then pumped to the sewage system, and the treatment plant is ready to take on new quantities of wastewater for treatment.

2.3. Technology of sludge processing and neutralization

Sludge is generated as a by-product of the chemical pre-treatment process and requires further treatment, either the separation of water, or the final neutralization. Sludge contains many toxic substances and carbohydrates as well. The content of water is also extremely high (about 92%), so it has to be squeezed out from the sludge. There are two possible procedures to process the sludge:

- by press,
- by a centrifugal water separator.

2.3.1. Press treatment of sludge

Liquid sludge is pumped to a separate filter power press. By pressing the filters, the excess water is squeezed out, and a compacted block ('cake') is formed. This cake can only be disposed of on a special waste dumping ground.

2.3.2. Sludge treatment by centrifugal water separator

In this procedure, the process of water separation takes place in specially designed centrifugal facilities. This technology is suitable for larger quantities of treated sludge, as it is much faster and more efficient in separating the water than press treatment on a filter press.

The product obtained by both technologies of water separation from sludge is the compacted cake. Abroad, this is dumped on specially structured dumpsites. However, there are no such dump facilities in Slovenia, and consequently the problem issue of sludge cannot be resolved adequately and finally by these two technological procedures.

2.3.3. Sludge Neutralization Technology

The only solution for our country, and in avoidance of all ecological problems, is in the use of the so-called sodification technology, which neutralizes the waste sludge to such a degree that it can be deposited on an ordinary public dumping ground. This can be achieved on a special machine plant which allows the regulation of the input sludge and live lime quantity. The chemical reaction triggered in the mixer is distinctively exothermic, which results in decomposition of carbohydrates.

After the mixing is finished, the mixture is left for at least 48 hours to 'mature', for the chemical reaction between lime and sludge to stabilize and cool down. After that, the produced cake is ready to be removed onto the public dumping ground as non-dangerous waste.

3. CONCLUSION

The purpose of this contribution is to draw attention to the complexity and diversity of technologies used in heavy-duty truck wash facilities, where vehicles carrying dangerous goods are cleaned. Concerning this topic, it could be expected that the technologies applied focus on how to achieve cleanness of the surfaces treated. On the contrary, the more advanced technologies concentrate on wastewater treatment (cleaning) and elimination of adverse impacts that could be inflicted on the environment.

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POVZETEK

MODEL TEHNOLOGIJE ČIŠČENJA ODPADNIH VOD IZ PRALNICE VOZIL ZA PREVOZ NEVARNEGA BLAGA

S pranjem se prav gotovo srečuje vsak lastnik osebnega vozila, nekateri bolj, nekateri manj pogosto. Seveda gre pri omenjenem pranju, oziroma čiščenju, predvsem za lepši izgled prevoznega sredstva.

V prevozništvu prav tako poznamo zahteve po čistih vozilih na cesti, saj je to vsem viden in pomemben zunanji element urejenosti vsakega prevoznika. Zlasti pri prevozu nevarnega blaga, pa obstajajo tudi drugi vzroki, zaradi katerih se moramo

posluževati tehnologije pranja prevoznih sredstev. Gre predvsem za razloge, ki jih zahteva sprememba vrste prepeljanega tovora, ali pa predpriprava vozila za sprejem na vzdrževalna popravila. Voda, katero uporabljamo pri tehnologiji pranja se med samim postopkom meša z ostanki predhodno prepeljanih snovi in je onesnažena do tolikšne mere, da je enostavno ne moremo spustiti v kanalizacijsko omrežje ali celo neposredno v vodotok, brez predhodnega čiščenja,

V članku je predstavljen model rešitve in sosledje tehnologij, potrebnih za uspešno sanacijo onesnažene vode iz pralnic, v katerih se vršijo predvsem pranja vozil, ki prevažajo nevarno blago.

KLJUČNE BESIDE

čiščenje, pranje, onesnažena voda, čistilna naprava, nevtralizacija, prevoz nevarnega blaga

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