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Content

Preface

This report has been commissioned by the Working Group for Products and Waste (WG PW) of the Nordic Council of Ministers. The report describes the existing possibilities to reduce the environmental impact from vehicle washes on the external environment.

The report addresses persons in charge of car washes, trade associations and environmental authorities. The project has been monitored by WG PW's working group on BAT (Best Available Techniques). The BAT group has the following members:

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Erkki Kantola, Northern Finland Environmental Permit Authority, Finland
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The Faeroe Islands

The BAT group works at a Nordic level to investigate and disseminate information about the possibilities of a more environmentally adapted production in areas with many small and medium-sized enterprises. The group shall contribute to the promotion of best available techniques, with special emphasis on cleaner technology in selected industries. The purpose is to reduce the strain on the environment as far as possible. This is in accordance with the declaration of the ministers at the Helcom as well as the North-Sea conferences, which mentions BAT as one instrument to ensure that emissions to the marine environment are reduced as far as possible. The conditions laid down in an emission permit shall, according to the IPPC (Integrated Pollution Prevention and Control) directive of the EU, rest on the best available technology.

The BAT group is subordinate to the Working Group for Products and Waste (WG PW), the task of which it is to ensure the implementation of the action programme of the Nordic Council of Ministers for cleaner technology, waste and recycling. The report is to be viewed as a constituent of this action programme.

Summary

The Nordic Council of Ministers, Working Group for Products and Waste (WG PW) has commissioned IVL, the Swedish Environmental Research Institute Ltd, to investigate best available techniques (BAT) to reduce the impact on the external environment from vehicle washes in the Nordic countries.

The sources of pollutants are spent detergents, material from the road, the vehicle, the washing equipment and from the wash-hall itself. The pollutants are oil, tensides, complexing agents and metals, among others. The plasticizer diethyl hexylphtalate (DEHP), which is a constituent of underbody coating, and polycyclic aromatic hydrocarbons (PAH), which occur in tyres, have also been found.

Half of all vehicle washings in the Nordic countries are carried out outside wash-halls/wash-sites, i.e. they are done on sites where no wastewater treatment is available. This poses a risk of pollution of subsoil water or receiving waters. To minimise discharges of pollutants:

- Use environmentally suitable chemicals
- Avoid solvent-type degreasing agents in summer
- Minimise the retail sale to private customers of environmentally unsuitable car detergents
- Reduce the number of vehicle washings at home or on wash-sites without water treatment facilities
- Dispose of waste from the washing at a certified processing plant. From a treatment and a cost-efficiency viewpoint this is better than separate disposal at each individual car wash.
- Dispose of waste containing chemical residues from used containers in compliance with local regulations.

Emissions to air peak in connection with high-pressure washing, when heavy aerosol formation occurs. A change to environmentally suitable chemicals low in aromatic hydrocarbons has improved the situation.

Unpleasant odours sometimes arise in the wash-halls. This is fairly easily remedied by preventing water from becoming stagnant. Suitable measures are forced circulation or aeration. Alternatively a strong oxidant may be added.

Noise may affect the surroundings. Suitable counter-measures are noise proofing of fans (shut them off at night) and adjusting the running of the driers to the opening and closing of the hall gates.

There are a number of different types of treatment plants installed to treat the washing liquids. The prevalent treatment systems in the Nordic

countries are sand traps + gravimetric oil separators. These systems do not work satisfactorily when microemulsions (mixtures of solvents and tensides) are used. Systems with additional treatment techniques are available. Most treatment systems on the market yield good treatment results. The factors decisive of a good function are self-supervision and good management and maintenance.

Treatment systems with additional techniques are more frequent in Sweden than in the other Nordic countries. In Sweden about 30 % of the automatic wash-halls have such techniques, oft with a high recirculation ratio. It should be possible to introduce additional treatment techniques at car washes with a large number of washings.

At service stations with few washes, usually the case in thinly populated areas, the most important thing is to use environmentally suitable detergents and to prevent the washing liquids from reaching the subsoil water or sensitive receiving waters. It should be possible to introduce simple and cheap water treatment systems to a greater extent than today. The electricity use of the treatment plants is low, < 1 kWh/car. Totally closed systems have a considerably higher consumption, 4-5 kWh/car, of which the evaporation uses 4 kWh.

In the near future the most frequently used techniques in the Nordic countries will still be sand traps and oil separators, with some simple additions. In Sweden more advanced treatment techniques will be necessary during the entire washing season in order to meet the stipulated emission requirements.

Membrane technology may become a new treatment technology at car washes, provided that certain products are replaced, e,g, waxes. Exchange of certain waxes for environmentally more suitable products has been done in Denmark with a good result, except when solvent-type degreasing agents are used. If the painted surface of the vehicle can be designed to repell dirt better than today, this will also be environmentally beneficial.

The tensides used in vehicle washing should be modified to give less stable micro emulsions. That will give smaller and cheaper treatment systems. The requirement is of course that the washing result is as good as earlier. The best way to minimise the discharges of pollutants from car washes is to totally close the entire system, of course. This is an option at large car washes only because of the high costs.

Several investigations have shown that chemical flocculation in existing conventional sludge and oil separators yields low emissions, whichever type of degreasing agent is being used. This method is definitely the most inexpensive additional technique. It can be used in both small and large systems. Good supervision and maintenance are required for a good result, however.

At service stations with very few washes the introduction of environmentally suitable detergents is the most efficient way to reduce the impact on the environment.

1. Background

The Working Group for Products and Waste (WG PW) of the Nordic Council of Ministers, has commissioned IVL, the Swedish Environmental Research Institute Ltd, to investigate best available techniques (BAT) to reduce the impact on the external environment from vehicle washes in the Nordic countries. Vehicles in this context are passenger cars, buses and lorries.

2. Market survey

The automatic car washes are often located at petrol stations and operated by these stations. The approximate number of automatic vehicle wash - halls are given in Table 1.

Table 1 Number of automatic car washes and number of washed cars in the Nordic countries

Country	Number of automatic washes	Cars washed(millions/a)
Denmark	1100	13
Norway	1000	14
Finland	900	10
Sweden	1100	16
Iceland	< 25	< 0,25
The Åland Islands	4	
Faeroe Islands	5	

In addition there are an unknown number of car-wash facilities, usually with manual washing, at car repair shops, car-sales establishments etc. In Denmark there are a little less than 300 such units, in Sweden 1,700–2,000 units, most of them do-it-yourself halls (about 1,700 units). In Iceland there are about 60 washes, of which 30–35 are free-of-charge washes connected to petrol stations. The Faeroe Islands and The Åland Islands have about 20 car washes each. Of these facilities 5 and 4 units respectively are automatic washes.

Denmark has the highest share of automatic washes; about 60 % of all washes in the country are automatic. In Norway and Sweden the share of automatic washes is 22 and 25 % respectively. As far as Finland is concerned the washing frequency is considered to be the same as in Sweden. For now it may thus be assumed that 25 % of the washings are carried out in automatic wash-halls. Half of all vehicle washings in the larger Nordic countries are not carried out in wash-halls but at home, at private garages etc.

Water treatment equipment (besides sludge and oil separators) has presently been installed at about 30 % of the automatic wash-halls in Sweden. In Denmark approximately 5 % of the wash-halls have such equipment, but in Finland, Norway, Iceland and the Faeroe Islands the share of establishments with treatment equipment is less than 5 %. On the Åland Islands there is only one establishment using advanced treatment technology.

The Nordic Swan has awarded environmental labels to car washes. In Denmark and Sweden there are today 14 and 11 Swan labelled units respectively. In the other Nordic countries there are only a few Swan labelled facilities.

Two water treatment plants for car washes in Sweden have obtained financing as demonstration projects from the Life programme of the EU. One of the plants had 80-90 % recirculation of the water. The other one featured a totally closed system. The treatment technologies used may be studied in the sections 4.2.3 and 4.2.9. In Denmark 95 % of all washing is done with brushes. In Sweden, Finland and Norway the share of brushless washing is about 25 %.

Denmark also differs from the other countries with 50 % of the washing facilities utilising water treated by ion exchange and reversed osmosis for the last rinse. This is done to get a better washing result and to prevent calcium stains from the tap-water from remaining on the car when it has dried. This technology has been introduced at only a few stations in the other countries.

All Nordic countries as a rule have sand traps and oil separators connected to the washes. At all new installations the goal is to install oil separators, which meet the European standard EN 858-1 and -2 (Separation systems for light fluids, such as oil and petrol). Parts 1 and 2 among other things describe the principles for dimensioning, designing, operating and maintaining the oil separators.

There are few guiding discharge values for car washes in Norway, Finland, Iceland, the Faeroe Islands and the Åland Islands. Usually only oil is monitored, for which the guiding value is 50-100 mg/l. to urban waste water treatment plant. Local regulations may, however, be used to prescribe lower concentrations and also the monitoring of other analytical parameters, for instance metals and nutrients, depending on the load on the municipal wastewater treatment plant and the sensitivity of the receiving water. Concentration of 1–15 mg/l if dischard to receiving water.

In Denmark and Sweden there are guidelines for oil and metals in the influent water to municipal treatment plants. They are given as mg/vehicle (see table 8 in section 3.1.1.). If a vehicle wash is connected directly to the surface water system and to the receiving water (as occurs in a few cases) the requirements are much stricter, for oil usually 1–5 mg/l.

The Environmental Management Board of the City of Stockholm and Stockholm Vatten AB have issued new and more stringent guidelines for vehicle washes (2005-11-01) in the city. Two alternatives are offered; either at least 80 % recirculation of water in addition to the previous (retained) discharge requirements, or no recirculation of water but significantly tightened discharge requirements. The oil index has been lowered by 50 % and cadmium by 60 % (see appendix 1).

In Denmark a thorough car wash investigation has been carried out for the Danish Environmental Protection Agency in project No. 537 2000 during 1999–2000 and project No. 876 from March 2002–January 2003. Project 537 "Bilvask - Status och strategier" (”Car wash - Status and Strategies”) describes the environmental impact of car-wash-halls and proposes strategies for municipal wastewater treatment and strategies to decrease the wastewater load from car-wash-halls (Stage I) as well as limits for oil, metals and DEHP (diethyl hexylphtalate).

Project No. 876 (Stage II) is a continuation of the project mentioned above. This latter project mainly deals with an investigation of three biological plants and one chemical-physical plant, where A- and B-chemicals (which are problematic) have been replaced. The water is recirculated at these establishments. An economic assessment was also carried out. A check on manual washing has furthermore been carried out. Forty cars were washed.

The investigation shows that the A- and B-chemicals replaced cationic tensides, oil distillates, alkyl sulphonates, siloxanes and EDTA, among others. Altogether about 20 new products were developed. All A-chemicals in the wax products were phased out. Ten new products without A- and B-constituents were designed. One of these products was tested at the four treatment plants. No complaints because of the new wax coat were registered from customers.

The recirculation ratio of the water was above 90 %. No disturbances of the treatment plants could be observed, nor were there any complaints from customers about a bad result of the wash or about bad odours.

Heavy metals were reduced by a factor of 10 compared to traditional wash-halls without treatment plants. DEHP was reduced by 95-99 % using the same methods of calculation, with the exception of one hall, where the limits were exceeded. In this case the explanation offered was that DEHP was set free from PVC material, which had been installed recently.

The results are reported in tables 2 and 3.

Table 2 Heavy metals, DEHP, petroleum oil and grease from the three sets of measurements

	Unit	Wash Tec in Slagelse Min-Max-Mean	Wash Tec in Herlev Min-Max Mean	CWS in Lyngby Min-Max- Mean	Team Wash in Fredrikssund Min-Max- Mean	Traditional-car wash-March 1999	Danish EPA limits
Lead	µg/l	2.3-5.7 4.0	3.2-39 15	2-6.7 4.4	8.3-27 16.4	32-150	100
Cadmium	µg/l	0.47-0.65 0.55	0.57-6.5 2.6	0.18-0.2 0.19	0.49-1.2 0.75	0.2-4.5	3
Chrom	µg/l	9.5-44 28	20-210 85	9.2-23 16	24-80 45	20-88	300
Copper	µg/l	84-210 130	150-800 370	13-90 52	120-880 397	93-410	100*
Nickel	µg/l	16-25 20	36-69 52	14-21 18	22-49 33	8-36	250
Zinc	µg/l	480-740 650	590-5 800 2 500	190-640 415	590-3 700 1863	635-5 800	3 000
DEHP	µg/l	4.7-17 13	3.2-100 36	5.1-50 28	15-270 108	17-260	7*
Petroleum oil	mg/l	< 5-8.4 5.5	< 5-6.6 3.9	0.39-9.4 4.9	< 5-14 8.3	0.25-48	10
Grease	mg/l	< 5	< 5-5.3 3.4	1.8- < 5.0 3.4	< 5-7.6 5.9	-	

Intended limit value as a manifestation of the long-term goal for the discharge.

Table 3 Calculated discharges per car from measurements on wastewater from the three sets of measurements

	Unit	Wash Tec in Slagelse Min-Max-Mean	Wash Tecin Herlev Min-Max Mean -	CWS in Lyngby Min-Max- Mean	Team Wash in Fredriks-sund Min-Max- Mean	Traditional car wash March 1999	The Swan[1)]	Target values from the stage-1
Wastewater discharge during weeks with sampling	l/car	4-13 7	8-18 14	1*	5-24 12	120-163		
Lead	mg/car	0.01-0.07 0.03	0.05-0.31 0.14	0.002-0.007 0.005	0.042-0.336 0.212	3.5-43 13		15
Cadmium	mg/car	0.003-0.006 0.004	0.01-0.052 0.025	0.002 0.002	0.003-0.012 0.008	0.1-0.9 0.34	0.25	0.45
Lead+chromium + nickel	mg/car	0.2-0.4 0.3	1.2-2.5 1.6	0.0322-0.0044 0.038	0.272-1.728 1.083	12.1-78 25	10	
Copper	mg/car	0.3-2.7 1.2	2.6-6.4 4.0	0.013-0.09 0.052	0.6-7.04 4.07	20.1-147 42	75	15
Zinc	mg/car	2-10 5.3	10-46 26	0.19-0.64 0.42	2.95-31.2 21.3	69-1500 309	50	450
DEHP	mg/car	0.02-0.21 0.11	0.05-0.8 0.3	0.005-0.05 0.028	0.195-2.16 0.905	4.1-66.4 17.4		1
Petroleum oil	mg/car	13-109 48	<- 53 47	0.32 0.32	<- 336 122	125-17148 2 250	1 500	1 500

* The water discharge is a mean value for the entire period, since CWS´s plant does not discharge water to the sewer during normal operation. [1)] Nordic type-I environmental label.

The investigations quoted above show, among other things, that some analysis parameters (Cu, Zn, DEHP) exceed the guiding limits of the Danish EPA measured as concentrations of pollutants, but thanks to a high recirculation ratio the requirements of the Swan label and the EPA limits are met by a margin. It is not possible to assess which of the units of the treatment plant have the highest treatment efficiency. Only the effluent water was sampled.

It is remarkable that no disturbances have occurred considering the fact that biological plants are sensitive to high salt concentrations. Such conditions should arise fairly quickly in winter due to the high recirculation ratio.

If the wash hall itself or the brushes are cleaned other and stronger chemicals are often used, which involves a risk of disturbances. The good result may be due to the fact that in Denmark strong degreasing agents are not used, and to the possibility that only limited salting of the roads was carried out during the sampling period. Another positive observation was that the substitutes for the wax products seemed to perform well.

The economic assessment concluded that the water treatment plant reached cost-benefit break-even at 10 - 15 000 car washings/a. This, however, is highly dependent on the cost and consumption of water.
Manual washes used 75-100 l/car. At normal water pressures ca 100 l/car were used. In these cases the guiding limits of the Danish EPA were exceeded for among others DEHP, lead, cadmium, chromium, copper and zinc.

The investigation comprised a limited number of washes. Further investigations were thus recommended, including an inventory of the washing agents sold in the shop.

In Norway tests of oil separators for car washes have been carried out for the Norwegian Petroleum Industry Association (Norsk Petroleuminstitutt) by Hjellnes Cowi A/S.

The main objective was to elucidate how the metal and oil discharges were reduced by an optimisation of the operation and the design of the washes and the water treatment plants.

In the proposal for regulations of wastewater discharges (the wastewater regulation) paragraph 2-2, "special requirements for the discharge of oil-containing wastewater", lays down the following requirements for car washes:

- 50 mg oil/l for new discharges from December 21 2003 och 50 mg oil/l for existing discharges from December 21 2004.
- Oil-containing water shall pass a sand trap and an oil separator dimensioned for the maximal water load without exceeding the limit concentrations. The proposal for the revised regulation contains no other discharge limits than for oil. However, municipalities have been given the option to formulate specific demands for heavy metals and for other analysis parameters, if in their opinion the municipal wastewater treatment plant will be disturbed or if the receiving water is sensitive..

The Norwegian Pollution Control Authority claims that further treatment with more advanced technologies to reduce the concentrations of metals should normally not be necessary. The costs are considered unreasonable when 90 % of the wastewater sludge from Norwegian treatment plants meets the stipulated requirements for heavy metals.

Sand traps and oil separators shall first of all be dimensioned to meet the oil requirement. Various combinations of washing detergents may cause the oil separation to be low, although the load on and the residence time in the oil separator are correct. It may then become necessary to add flocculation chemicals in order to improve the separation rate.

There are no limits as to the amount of water that may be used to wash a car. Sweden previously had such a requirement, 50 l for a passenger car and 150 l for a heavy vehicle to the sewer. The requirements for discharged pollutants, measured as quantity per vehicle, have not been changed, however, which in practice means that the consumption of water is low anyway, since recirculation is usually necessary to keep the stipulated discharge values.

The Norwegian inquiry quoted above has investigated 13 car washes, 9 automatic ones and 4 DIY washes. Different washing detergents and geographical locations were investigated (see table 4.)

The water consumption was approximately as follows:

- Self-wash 100 l/car
- Automatic, high pressure 400 l/car
- Automatic, combined 500 l/car

Table 4 Average discharge concentrations of oil and heavy metals. (The given values are before tests of measures to reduce the concentration of oil in the wastewater)

Type of establishment	Season	Oil mg/l	Pb µ/l	Cd µ/l	Cu µ/l	Ni µ/l	Zn µ/l
Wash-halls	Winter	69	42.5	2.45	240	17	780
			*(29.7)**	(0.3)	(128)	(12)	(167)
	Summer	34	53.8	1.5	191	17.5	769
			(34.4)	(0.4)	(124)	(11.8)	(307)
DIY establishment	Winter	290	66	2.45	276	23.7	670
			(53)	(1.3)	(176)	(14.7)	(307)
	Summer	98	61	1.2	400	18	585
			(45)	(0.47)	(247)	(6.4)	(237)
SFT requirement***		< 50	50	5	200	50	0

* Total concentration (dissolved + suspended). ** The numbers in brackets give the concentrations in suspended-particle form. *** SFT is the Norwegian Pollution Control Authority.

The table shows, that several analysis parameters exceed the guiding limits of the Norwegian Pollution Control Authority. Table 5 reports the oil discharges when various kinds of degreasing agents are used.

Table 5 Oil concentrations in the wastewater in relation to type of chemical and season

Wash establishment	Season	Petroleum based	Micro emulsions	Alkaline detergent	ST car wash
Wash-halls	Summer	6-250 (93)*	25-50 (41)	4-49 (29)	2-13 (7)
	Winter	220-670 (390)	18-89 (62)	7-68 (29)	43
DIY establishment	Summer	23 -1 80 (88)			8-13(11)
	Winter	220-620 (380)			43

* Mean values in brackets

The discharge values are of the same order of magnitude as those measured in Sweden in the early nineties for similar degreasing agents.
The tables 6 and 7 show concentrations and discharged quantities per car for automatic halls and DIY halls.

Table 6 Discharge of oil and heavy metals per car from wash-halls

Parameter	Concentration mg/l	Discharge per car at 450 l/car	Discharge per car Average in the Nordic countries	Swan-label requirement
Oil	10-200	4.5-90 g	28-35 g	1.5 g
Copper, Cu	0.05-0.43	22.5-194 mg	110-235 mg	75 mg
Zinc, Zn	0.35-1.2	158-540 mg	220-470 mg	50 mg
Nickel, Ni	0.005-0.04	2.3-18 mg	47-65 mg	10 mg
Lead, Pb	0.02-0.1	9-45 mg	47-65 mg	10 mg
Cadmium, Cd	0.0005-0.003	0.23-1.4 mg	0.9-1.6 mg	0.25 mg

Table 7 Discharge of oil and heavy metals per car from DIY halls

Parameter	Concentration mg/l	Discharge per car at 100 l/car	Discharge per car Average in the Nordic countries	Swan-label requirement
Oil	38-150	3,8-15 g	28-35 g	1,5 g
Copper, Cu	0.12-0.43	12-43 mg	110-235 mg	75 mg
Zinc, Zn	0.34-0.78	34-78 mg	220-470 mg	50 mg
Nickel, Ni	0.012-0.035	1.2-3.5 mg	47-65 mg	10 mg
Lead, Pb	0.028-0.12	2.8-12 mg	47-65 mg	10 mg
Cadmium, Cd	0.001-0.002	0.1-0.2 mg	0.9-1.6 mg	0.25 mg

The share of metals from car washes in the influent water to the wastewater treatment plant at Sandefjord has also been measured. For the hazardous metal cadmium this share was 7,5 %. In Sweden cadmium shares of 6 and 20 % from wash-halls were measured in the late nineties at the municipal wastewater treatment plants in Karlstad and Gävle respectively. These quantities have been substantially reduced, however, since cadmium has been phased out of several materials. Many car washes (about 1/3) have introduced treatment technology with recirculating water. This has minimised the discharges.

In the course of the Norwegian investigation a test with addition of various flocculation chemicals was carried out. Samples of the effluent from the oil separator with and without flocculation chemicals were taken.

A polyaluminium chloride dosage of 0,4 mg/l + polymer yielded the following result:

Sampled water	pH	Olja mg/l	Pb µ/l	Cd µ/l	Cu µ/l	Ni µ/l
Before chem. flocc.	9,7	180	44	1,1	430	13
After chem. flocc.	6,9	34	2,3	~0	31	13
% Reduktion		81	95	~100	9,3	0

The flocculation technique thus yields a good treatment result. Similar results have been obtained in Sweden, with good reductions of the nickel and zinc concentrations as well. Probably the pH-value was not the optimal one in the experiments reported in the table above. Nickel is best precipitated at pH-values above 9.

A few tests to polish the effluent from the oil separator with a coalescence filter and a bark filter were also carried out. The reduction rates were low. It should be possible to improve the reduction rates by optimising the combination of chemicals used.

The conclusions of the Norwegian investigation were among others that:

- The type of washing chemical is of the utmost importance to reach low discharges.
- the concentrations of oil are higher at do-it-yourself washes. This is due to the fact that the car owners use various chemicals they have brought themselves, and to the fact that the amount of water used is lower than at automatic washes, 100 and 450 l/car respectively.
- a coalescence filter had no effect on metals.
- chemical flocculation reduced lead, cadmium and copper
- by > 90 %. The separation of nickel and zinc might
- probably have been higher too, if the pH of the water had been optimised.
- when equipment is replaced or new equipment installed stainless steel and chemicalproof plastic and rubber materials should be used.
- better regulation of purchased washing detergents.
- do not use petroleum type detergents in summer.
- introduce better operating and supervision routines at the wash establishments.

The most common treatment techniques used in the Nordic countries are the following ones:

- Sand trap (ST) + gravimetric oil separator (OS) with or without recycling of water for the underbody flushing.
- As above but with addition of chemical flocculants.

There are a number of other treatment methods, which are established mainly in Sweden. They are supplements to sand traps / oil separators to make it possible to recirculate water and chemicals. The following treatment systems are available on the market:

- ST/OS + chemical flocculation + flotation or settling.
- Chemical flocculation + ST/OS + sand filtration.
- ST/OS + biological treatment + tilted plate settling
- ST/OS + hydrocyclone + electrolytic splitting.
- Counter-current rinsing + chemical flocculation + ST/OS + sand filtration + evaporation.

Several of the supplementary techniques may be used with other combinations of e.g. sand filtration and hydrocyclones, and some of them use oxidation techniques in the systems as well.

The recirculation ratio of the four first-mentioned techniques is usually about 80 %. However, recirculation ratios of 0 – 30 % are also found. The fifth system, which has evaporation as one process stage and which expels salt from the system, is completely closed (no water to the sewer).

In the Nordic countries the Swan is a joint symbol of the Nordic eco-labelling. There are swan-labelled products for car-maintenance and environmentally labelled car washes, among other things. These guidelines are stricter than the guidelines which normally are found for vehicle washes in the Nordic countries. The existing guidelines are published on the pertinent websites of each country (www.ecolabel.dk, www.ecolabel.no , www.sfs.fi/ymparist/, www.svanen.nu, www.ust.is/Umhverfismerki/Svanurinn/).

3. Environmental impact

Vehicle washes exert an environmental impact on receiving waters and on the air and by the generation of waste. Noise from the establishments may sometimes be a nuisance to neighbours.

3.1 Emissions to water

3.1.1 General considerations

Car washes have the following main sources of pollution. The essential pollutants are given in brackets.

- Road mud, which accumulates on the vehicles (asphalt, salt etc.)
- Cold-degreasing agents, microemulsions and alkaline water-soluble degreasing agents (oil, tensides, complexing agents)
- Car shampoos and foam products (tensides)
- Wax products (cationic tensides)
- Rim cleaners; degreasing agents (oil, tensides), but there are also acid cleaners.
- Hall cleaners; various agents, basic ones (oil, tensides, complexing agents) as well as acids.
- Flocculants (aluminium salts, orthophosphates + polymers)

In winter, when salt and studs are used causing release of particles from the road surface and the tyres, the load on the water treatment plants are higher. Larger amounts of chemicals and more potent chemicals are used too.

Pollutants, which are conveyed to the sewer, consist of:

- oil and tensides etc. from the detergents
- metals released from the vehicle and from various parts of equipment in the hall.
- zinc from among other things the tyres and from equipment parts.
- PAH (Polycyclic aromatic hydrocarbons) mainly from the tyres
- the plasticizer DEHP (diethyl hexylphtalate) from underbody coating and from jointing compounds.

The largest discharges to water occur when the treatment plant is badly maintained, by break-downs or by poor treatment equipment.

There may also be a danger of polluting discharges, when other degreasing agents than those used in the hall are sprayed at the car immediately before entering the hall or if the sewer of a car repair shop or engineering workshop is connected to the treatment system.

Other detergents used to clean the hall may influence the treatment efficiency negatively and cause too high discharges from the treatment plant.

Settled sludge, which is removed for central treatment, may later on have an environmental impact on receiving waters.

During functional tests in Sweden the following analysis parameters are checked: pH, oil, cadmium, lead, chromium, nickel, copper, zinc. In addition the ratio of BOD to COD is measured in order to assess the biodegradability. In Denmark DEHP and PAH have also been checked.

At certain reference plants, where very thorough tests of the performance of the treatment plant have been carried out, acute toxicity according to Microtox and inhibition of nitrification were also analysed. The Microtox method in short means that the ability of certain bacteria to generate light is inhibited by pollutants in the sample. This inhibition is measured. In the nitrification test the inhibition of the ability of the micro-organisms to convert ammonia to nitrate is measured. The Microtox test mainly pertains to discharges to receiving waters while the nitrification test essentially is applicable to discharges to municipal treatment plants. Most of these checks have been carried out in Sweden.

The discharge levels from automatic car washes in the Nordic countries are given in the first column of Table 8, together with guidelines for the amounts of discharged pollutants.

Table 8 Amounts of discharged pollutants, mg/car

Analysis parameters	Sweden/Denmark Measurements	Nordic Ecolabelling Guidelines	Danish EPA Limits	Sweden Guidelines
Cadmium	0.01-1.6	0.25	0.45	0.25
Lead+chromium+nickel	5-65	10	15 (Pb)	10
Copper	2-100	75	15	-
Zinc	10-470	50	450	50
Oil	1 000 – 35 000	1 500	1 500	5 000
DEHP	1 - 50	-	1	-

The results of the measurements have been taken from investigations by Aqua Konsult AB, Stockholm Water, OK (the Oil Consumer´s Cooperative Society), SWECO AB, the Danish Hydraulic Institute (DHI) and the Swedish Environmental Research Institute (IVL). The measurements were carried out between 1994 and 2003 at about 75 establishments, equipped with treatment plants ranging from just sludge and oil separation to additional treatment with 0 – 90 % recycling of water.
The guidelines for Sweden are taken from the trade facts for vehicle washes, Swedish EPA 2005..

The Danish proposals for guidelines are from the Danish EPA´s projects 357 and 876 in 2000 and 2003, respectively.
The guidelines of the Nordic ecolabelling may be studied in the document "Ecolabelling of Car Washes" (Miljömärkning av biltvättanläggningar, in Swedish), criteria paper, October 6 2000–October 6 2005, version 1.5.

Environmentally suitable chemicals should be used. This means among other things that the constituents must not be toxic, bioaccumulating or difficult to degrade. The analyses are performed according to the OECD Test Guidelines.

Guidance as to which chemicals to use may be obtained from among other sources: Nordic Ecolabelling or the EU Flower .

3.1.2 Measures to minimise discharges

Introduction of one or a few of the measures listed below will minimise the polluting discharges from vehicle washes.

Automatic and manual wash in vehicle halls

- Use of chemicals: Solvent type degreasing agents should possibly be avoided in summer, April/May – September/October, when the load of asphalt mud is lower. In Denmark solvent type degreasing agents are already avoided during the whole year. Environmentally suitable chemicals should be used as far as possible in the Nordic countries.
- Installation of a completely closed system. Such a system is free of discharges but requires a large number of washes to be cost-efficient.
- Installation of additional treatment techniques. Supplementing sand traps and oil separators with additional treatment stages offers an opportunity to recirculate water. Various recirculation technologies yield water savings, as described in section 5.3. Investigations have shown, that the discharges are reduced (by 80–99 %), when sand traps and oil separators are supplemented with water-reclaiming technology.
- Installation of sand traps and oil separators. Use sand traps and oil separators according to the EU standard EN 858-1 and -2
- Corrosion-resistant material. Wash-hall, washing machine and water treatment system should be made of corrosion-resistant materials at new installations.
- Alarm devices. Important functions should have alarms, indicating e.g. incorrect pH-values and pump breakdowns, and supervising level monitors at existing overflows or levels in tanks for chemicals.
- Shutting off the water treatment system. When important alarms are triggered concerning functions, which affect the discharges, the system should be shut down immediately.

- Management and maintenance, keeping of journals etc.Self-supervision, keeping of a journal and training of the staff are probably the most important work operations at a treatment plant, if it is to deliver the desired result (see section 7 about management).

Washing at home etc.

In order to decrease the environmental impact of car washing, it is important to transfer it from private homes to wash-halls equipped with water treatment systems to as high an extent as possible. If cars are washed at home it is a matter of course that environmentally suitable washing detergents should be used to minimise the environmental impact.

3.2 Chemicals

3.2.1 General considerations

According to oil companies and suppliers of chemicals the same types of chemicals are by and large used in all Nordic countries. In Denmark strong degreasing agents like petroleum (white) spirit are not used, however. Instead various shampoo and foam products are used to clean the cars.

In Denmark the car-washing chemicals are classified in the categories A, B and C according to the danger they pose to the environment.

List A comprises compounds undesired in the wastewater, e.g. because they are not easily degradable or because they are very toxic to water-living organisms or because they may harm human beings. They should be eliminated from the wastewater by substitution. If this is not possible, their use should be reduced to a very minimum.

List B includes compounds, the use of which is to be limited by applying BAT, which means that environmental requirements may be met (Guidelines of the Danish EPA for connecting industrial wastewater to municipal wastewater treatment plants, “Miljøstyrelsen Vejledning om tilslutning af industrispildevand til kommunale spildevandsanlæg”, in Danish). The C category consists of compounds which normally are unproblematic. As a general rule the precautionary principle should be applied for chemicals of all categories.

An environmental assessment showed that the discharges of compounds of the A, B and C categories were 28, 39 and 220 tons/a from vehicle washes in Denmark .

The Nordic countries comply with the recently passed EU directive REACH. It deals with the risks of hazardous chemicals and comprises commercial vehicle chemicals as well.

Chemicals

When vehicles are washed, various kinds of detergents and other products, such as degreasing agents and shampoos, are used. The contents and functioning of the products may summarily be described as follows:

Cold-degreasing agents (solvent type) contain mainly petroleum hydrocarbons and 2 – 4 % tensides. Petroleum-based cold-degreasing agents may consist of normal paraffins (C_{10} – C_{13}) and naphtha free of or low in aromatic hydrocarbons.

Degreasing agents based on vegetable products containing esters of fatty acids from e.g. rape and coconut are also available.

Microemulsions are degreasing agents with a lower content of petroleum hydrocarbons than the usual degreasing agents, about 5 – 30 %. The hydrocarbons are emulsified in the water with the aid of 5- 20 % of tensides.

Alkaline degreasing agents consist of an aqueous solution of alkali (5-20 %), such as sodium metasilicate, potassium or sodium hydroxide, tensides (5 – 10 %) and complexing agents (e.g. NTA) etc. The pH-value of the products in solution ready for use may be about 12.

Shampoo contains essentially water and tensides, but other compounds may be present as well, such as alkali and complexing agent. There are several types of shampoos. In automatic washes foam shampoos and brush shampoos are used, for instance. Foam shampoo is a mild alkaline shampoo. It is mostly used in summer. It is applied with air to create foam during washing. Brush shampoo is used in brush-washing machines and also helps clean the brushes. Brush shampoos may besides water and tensides contain solvents (e.g. alcohols) and complexing agents. Wax shampoos are another type of shampoos with emulsified waxes.

Waxes are used to give the car paint a protective coat. Waxes contain hydrocarbons with carbon chain-lengths of about C_{24} – C_{34}. Examples of available waxes are so called montan (lignite) wax and carnauba wax, which have respectively a synthetic and a natural origin.

Common types of waxes for car reconditioning are pure (hard) waxes and dissolved (liquid hard) waxes. Liquid waxes also contain solvents like petroleum spirit. In automatic washes combined products with both wax and a rinsing agent, so called rinsing wax, are often used.

Run-off/rinsing agents are used in automatic washes to facilitate the drying of the car. They are thus also called drying agents. The products often contain cationic tensides, which create a water-repelling surface film through a high attractive force to paint surfaces.

There are special products to clean car rims. These may be composed of an aqueous solution of alkali salts, complexing agents, alcohols (e.g. 2-aminoethanol) and tensides.

As a rule the use of products for vehicle washes is adjusted to the season. In case of severe mud conditions in winter more degreasing agent is used. The degreasing agents may vary from alkaline products in less severe circumstances to microemulsions or petroleum-based degreasing agents under more severe conditions. In summer, when the need for degreasing is not that urgent, the products are often diluted with more water, and often only alkaline detergents or shampoos are used.

The table below exemplifies the use of chemicals at an automatic wash with a portal washing machine for cars in summer and in winter. Note that the use of products varies depending on the choice of washing programme and the type of degreasing agent used. There may be differences in recommended quantities and dilution ratios between different suppliers of washing machines and chemicals.

Table 9 Examples of the use of chemicals at a car wash

Product	Summer	Winter
Alkaline degreasing agent	1,5-1,8 litres/wash, of a 4 % solution ready for use	1,5-2,5 l/wash of a 10-20 % solution ready for use
Microemulsion	-	1,5-2 l/wash of a 10-20 % solution ready for use
Cold degreasing, petroleum-based	-	0.3-1 l/wash
Foam shampoo	1-3 cl/wash	1-3 cl/wash
Brush shampoo	3-5 cl/wash	5-8 cl/wash
Wax	2-4 cl/wash	2-4 cl/wash
Run-off/rinsing agent	2-4 cl/wash	2-4 cl/wash

Washing bigger vehicles will obviously consume more detergents. Automatic washes of lorries and buses may consume about 15 litres/vehicle of solutions ready for use of either alkaline detergents or microemulsions (vehicles 12 m long). Examples of concentrations of active substances in solutions ready for use are 4 -10 % for alkaline detergents and 10 – 20 % for microemulsions. An additional degreasing agent is often applied manually with a hand-sprayer to certain parts of the vehicle to get it completely clean, especially in winter. When washing a lorry this may mean that up to 10 more litres/vehicle of a detergent (e.g. a 20 % solution of a microemulsion) are consumed. Cold-degreasing agents are also used in these situations.

Flocculants

Various types of process chemicals, like precipitants or flocculants and pH-adjusting agents, are used for chemical treatment of wastewater from vehicle washes. Polyaluminium chloride and orthophosphate are examples of precipitants and flocculants. The pH-value is often adjusted with caustic soda or lime.

Other cleaners and germicides

Degreasing agents and other cleaners are used to keep the wash-halls clean. They may be petroleum-based or of an alkaline type. Acid cleansing substances are also used to remove e.g. deposits of lime.

Germicides or agents against odours may be used in wash-halls with water recycling. The most frequently used ones are hydrogen peroxide, UV irradiation and ozone.

Additional remarks

The solvent type detergents are more efficient cleaners, above all against stains of asphalt. Other types of mud are just as efficiently removed by the alkaline water type detergents. From an environmental point of view the alkaline water type detergents are preferable. The totally closed systems use solvent type degreasing (low in aromatic hydrocarbons). This may be acceptable, since the washing liquid is not entering the wastewater and since employees carrying out manual hígh-pressure washing are supposed to wear protective clothing because of the aerosol mist in the hall.

3.2.2.Measures to minimise the use of chemicals and to use eco-alternatives.

Below we list some measures to reduce the use of chemicals and to use environmentally sound alternatives:

- Records of chemicals in use shall be kept in the hall and communicated to authorities concerned. The suppliers of chemicals shall provide safety sheets describing the physical, the toxicity and the degradability properties and the risk management etc.
- Environmentally hazardous chemicals like nonylphenols are being phased out of the Nordic countries.
- Guidance about environmentally suitable chemicals for vehicle washes are available through the Nordic Ecolabelling, the EU flower etc.
- Recycling of water means lower consumption of chemicals, of shampoos and foam detergents above all.
- Brush-washing machines consume only 25 – 30 % of the chemicals used by high-pressure machines without brushes. This means that the consumption of chemicals is lower in Denmark, since about 95 % of the washes there are done in brush-washing machines.
- Proper handling and maintenance of the washing and the water treatment equipment are important to prevent an unduly high consumption of chemicals.
- If the strong, i.e. the solvent type, detergents can be avoided in summer, this will heavily reduce the amount of problematic chemicals. Since there are no studs to tear up asphalt during the summer, such a measure should be possible. In e.g. Germany and Denmark no solvent type degreasers are used, just shampoos and foam detergents.
- Minimise the shop-sale of environmentally unsuitable car detergents to private customers.

3.3 Waste

The generated waste consists of concentrated car mud, spent detergents and flocculants etc., which were described as emissions to water above. Generated sludge is collected in sludge drains inside the hall, in sludge and oil settling basins, which are often located outside the wash-halls and under the ground, in collecting containers for flotation sludge etc.
The sludge is normally removed by gulley emptiers and transported to a central treatment company, where sludge and water are further treated with a variety of methods, such as:

- gravimetric sludge and oil separation, oil-emulsion coagulation with heat or acids, biodegradation by composting, membrane filtration, evaporation or filtration of the liquid through peat followed by discharge to a wetland.

After dewatering and composting the waste is landfilled. Part of it is incinerated and part of the oil is reclaimed.

So called “sludge-farming” has also been practised. This means that the oil is harrowed down into a 10–20-cm layer of soil, which is fertilised. The degradation of the oil takes 3–5 years. The method is not satisfactory, since the metals remain. Other kinds of waste at the wash-halls are various used containers (cans etc,) with chemical residues. These are handled in accordance with local regulations.

3.3.1 Waste minimisation

- The volume of waste in the liquid phase may be somewhat reduced by biological degradation of the oil and of other organic compounds. The metals, however, remain.
- The flotation sludge from chemical flotation plants is dewatered by draining in drainer baskets. Better draining is reached with filter presses, but they are too costly compared to drainer baskets or transport to a central treatment facility.
- Gravel and sand, which end up in the sludge drains and the first basin (the sand trap) of the water treatment system, cause the largest waste volumes from the water system.
- If part of the water from sludge suction of the water treatment system is recycled, the volume of waste is reduced. Recycling water means a risk of too high a concentration of salt in the water, above all in winter. If so, the entire volume of waste must be removed.

Minimising the volume of waste at the wash-halls is expensive. It is more efficiently done at central treatment facilities.

- At bigger wash-halls a sand-wash may be installed to minimise the volumes of waste.
- If detergents and flocculants are delivered as concentrated and not as dilute solutions in large containers, the amount of waste and the road transports will be decreased.
- Plastic containers and cans may be chopped in special machines on the spot. This requires safe handling of chemical residues.

3.4 Emissions to air

Emissions to air have their origin mainly in the aerosols, which are formed, when the vehicles are washed. The formation of aerosols is most severe by high-pressure washing. Aerosols are discharged through the ventilation system. The emissions consist of a mixture of spent detergents. These emissions should have decreased, when chemicals better adapted to the environment were introduced. Such chemicals have a considerably lower volatility (e.g degreasing agents low in aromatic hydrocarbons (< 0,5 %).). Older degreasers contained up to 10 % aromatic hydrocarbons, which were released directly into the air when washing. The emissions have mostly an impact on the local environment.

3.4.1 Measures to minimise emissions

- Use low-volatile detergents.
- Use brush-washing instead of high-pressure washing. This will reduce the aerosol mist and thus the emissions to air as well.
- The design of the drying and ventilation systems also influences the emissions to air.
- One could try to shut off the driers in summer. That will save energy.

3.5 Odour and noise

Odour is often caused by stagnant wastewater in the treatment system, mostly in summer when the conditions favour bacterial growth. In most cases it smells of hydrogen sulphide (”rotten eggs”), and the pH-value of the water has fallen. The odour is felt in or in the immediate vicinity of the hall.

Solvent type chemicals also give off odours, especially at manual washes, where people are less protected than at automatic washes.

Noise, which may be perceived as a nuisance, is caused by washing machines, driers, fans and pumps etc., the wash-hall, the water treatment system and the traffic to and from the wash-hall. The noise may be disturbing in or in the immediate vicinity of the hall. How much of a nuisance the noise is to the neighbourhood depends on the siting of the hall.

3.5.1 Measures to minimise the environmental impact.

- Odours are minimised by preventing stagnation of water. Stagnant water may become anaerobic, which causes unpleasant odours. This is prevented by keeping the water moving in the system, by aeration and by keeping the pH above 6. If this is insufficient, treatment with hydrogen peroxide, UV irradiation or ozone may be introduced.
- Noise-muffling measures are:
  - enclose fans or put up muffling screens around them.
  - adjust the operation of the drier to be shut down, when the doors of the hall are opened.
  - install mufflers at the ventilation system.
  - Shut off fans (above all at night) when no washing is done.
  - Point the exhaust of the ventilation system away from buildings as far as possible.
  - It is easier to optimise the duct and fan systems when new equipment is installed or more extensive reconstruction is carried out.

4. Wash establishments and water treatment systems

4.1 Wash establishments

Automatic washes

The following types of automatic washes are used in the Nordic countries:

- Brush washes working with a water pressure of 3–4 bars.
- Brushless washes working at a high water pressure of 80–90 bars.
- Combinations of the two above-mentioned types.

The equipment may consist of:

- Roll-over machines. These are portal wash machines, which move over the standing vehicles.
- Wash tunnel. The vehicle is pulled by a chain winch through the wash, which has fixed rails for detergents and water.
- Wash lane. The washing equipment is stationary. The vehicles are driven through the wash-hall. This type of wash is frequently found at bus-washes.

The wash tunnels and wash lanes as a rule have a very high washing capacity.

The bigger wash establishments, which use one of the washing technologies listed above, have installed water treatment systems. Smaller wash establishments use roll-over machines with and without brushes, separately or in combination. The energy use of the wash establishments mentioned above are between 0,5 and 1 kWh/wash, including drying.

Manual wash sites

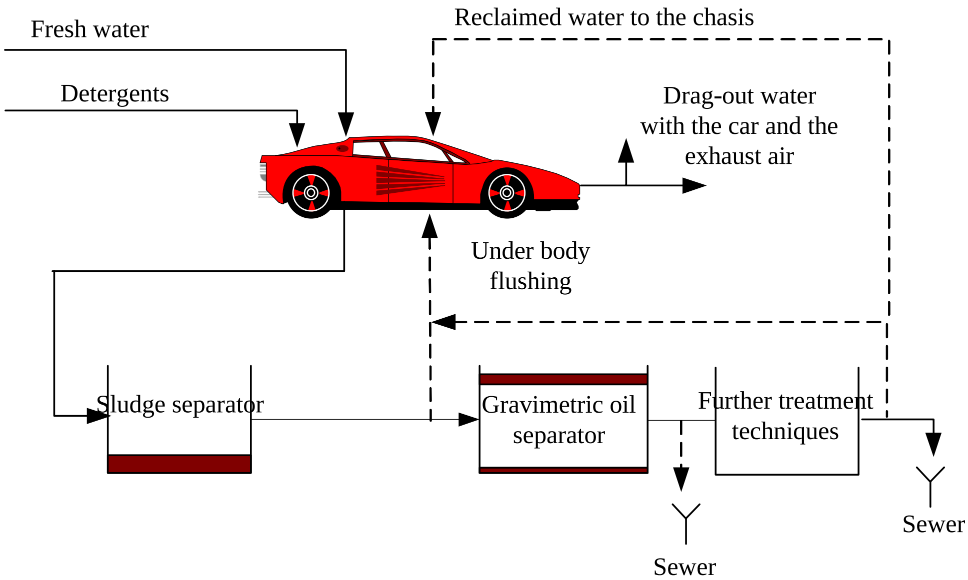
Manual wash sites may be DIY halls, washing places at car repair shops and car-sales establishments, washes for delivery cars of food and beverage manufacturers. These car-washes usually use manual high-pressure washing.

Other types of washing

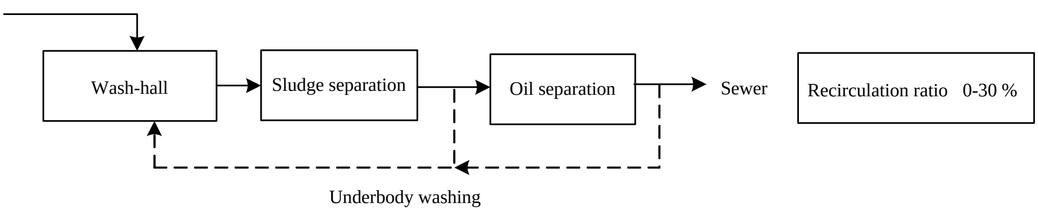
At home, at the garage and at similar places manual washing with a rinsing hose and just a bucket of water, with or without a brush, is usually practised. As a rule there is no separate water treatment system. The dirty water may find its way into waste or surface or even subsoil water.

4.2 Water treatment systems, function and recirculation ratios.

Essential outlines of the various treatment systems for vehicle washes, with and without recirculation, will first be described. Then simple principle sketches of most of the treatment systems, which exist on the Nordic market, will be presented. The most common ones are gravimetric sludge and oil separators, without and with chemical flocculation. More than 25 treatment plants have been studied as representatives of the technologies given below.



4.2.1 Gravimetric sludge and oil separation



Most of the heavy particles, like sand, settle in the sludge separator. The oil shall separate to the surface in the following oil separator.

The oil separator is normally designed to cope with a hydraulic load of 1 m/h (m^3/m^2 and hour) and a residence time of one to two hours. If the settling unit is equipped with tilted plates, a considerably higher load may be tolerated. The clarifier then requires less space. Settling clarifiers without tilted plate sets are the most common ones, however. Usually they are situated underground near the wash-hall.

Sometimes the water is recirculated after the oil separator. This yields purer water. The disadvantage is that the oil separator must then be designed for twice the flow. Usually water for the underbody flushing is taken already after the sand trap, which means that the oil separator may be dimensioned for a lower load. The recycling rate of water for underbody flushing is in most cases about 30 % of the influent.

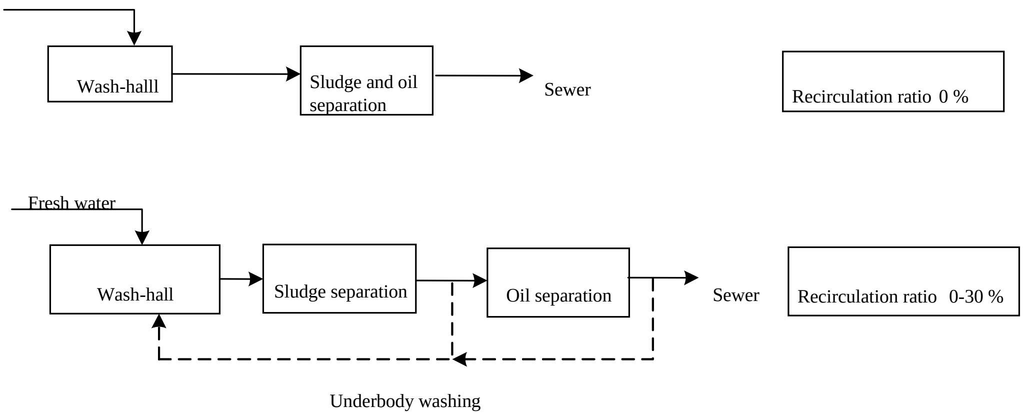
In the Nordic countries the treatment systems described above are the most abundant ones, and they have been in use for a long time. If microemulsions are used for degreasing, an oil emulsion forms, causing a poor functioning of the oil separator. The issued guiding values will then at times be exceeded.

The energy use of the treatment systems now described is low, < 0,5 kWh/wash.

The investment cost to install a sludge and oil separator is between 100 000 and 150 000 Sw. cr. for a capacity of 10 000 washes per year. There are additional costs for preparation of the ground. These costs may vary depending on the conditions at the site.

The investment costs for the treatment systems below (sections 4.2.2-4.2.9) are given excluding piping and any necessary building.

4.2.2 Chemical flocculation + sludge and oil separation



Chemical flocculants (usually aluminium salts or phosphates with polymers) are added in order to coagulate the oil emulsion and improve the separation of other pollutants. A correct pH adjustment is important to optimise the flocculation and the separation.

Unlike the previous situation the bulk of the oil will be trapped with the sludge in the sand trap and the oil separator. The oil layer in the oil separator will thus be considerably thinner than before, when cold degreasing agents were used.

When underbody flushing is applied the reuse of water is in most cases about 30 %.

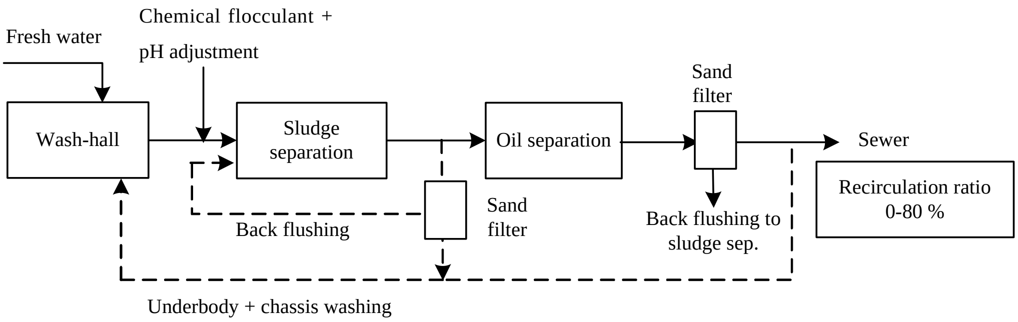
The technique described above was introduced starting in the middle of 1990´s, when microemulsions replaced the cold degreasing agents. This resulted in the formation of oil emulsions in the gravimetric separation systems. The separation became poor. For this reason chemicals were added to coagulate the oil emulsions. The technique is frequently applied in Sweden.

If the chemical flocculation and the pH adjustment are optimised the treatment efficiency will be good, and regulations will normally be met, provided that maintenance and supervision are satisfactory.

The energy use of the treatment system described above is low, < 0,5 kWh/wash.

The investment cost of the treatment system is between 150,000–200,000 Sw. cr.

4.2.3 Chemical flocculation + sludge and oil separation + sand filtration



The purpose of the sand filter is to further polish and reduce the quantities of discharged pollutants. However, it also serves as an additional safety device in case of up-stream troubles in the treatment system.

Usually pressurised sand filters of the downward-flow type are used. They may be backflushed at a certain preselected pressure, but in most cases the backflushing is controlled by a timer, set to e.g. backflush every 4 hours or every 24 hours, depending on the load of pollutants. The backflushing water is as a rule conveyed back to the sludge drain or the sludge separator of the wash-hall.

Other filtering techniques are also used to polish the effluent from sludge separators: Coalescence filters (coagulation of finely divided oil drops to bigger drops), specially treated peat/bark or activated carbon to reduce oil and metals. The last-mentioned appliances are not backflushed but replaced when they become saturated with impurities.

When water is recirculated for underbody and chassis washing the recirculation ratio is normally about 80 %.

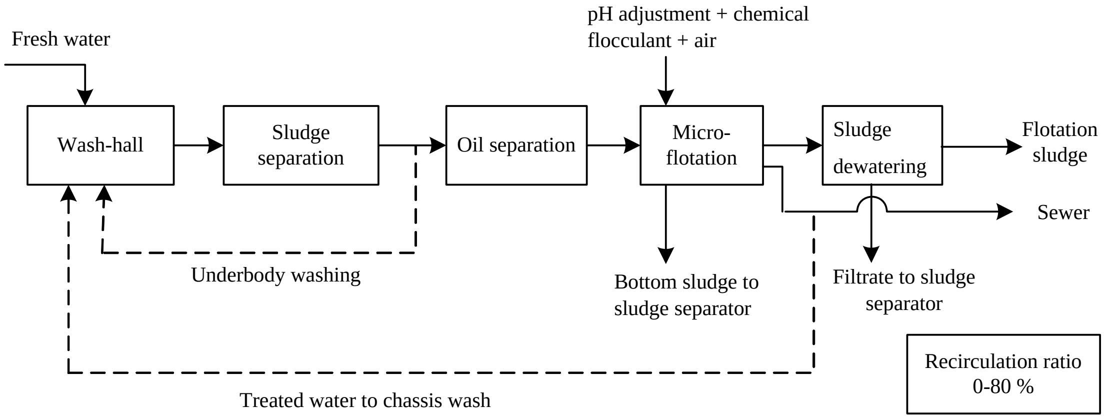
The introduction of these systems started in the middle of the 1990´s. They are (about 10 % of all new installations).

If the plant is well maintained and supervised the separation of oil and metals is 80–90 % (at 80 % recirculation of water).

The energy use of the treatment system described above is low, < 0,5 kWh/wash.

The investment is between 200 000 and 300 000 Sw. cr..

4.2.4 Sludge and oil separation + chemical flocculation + microflotation



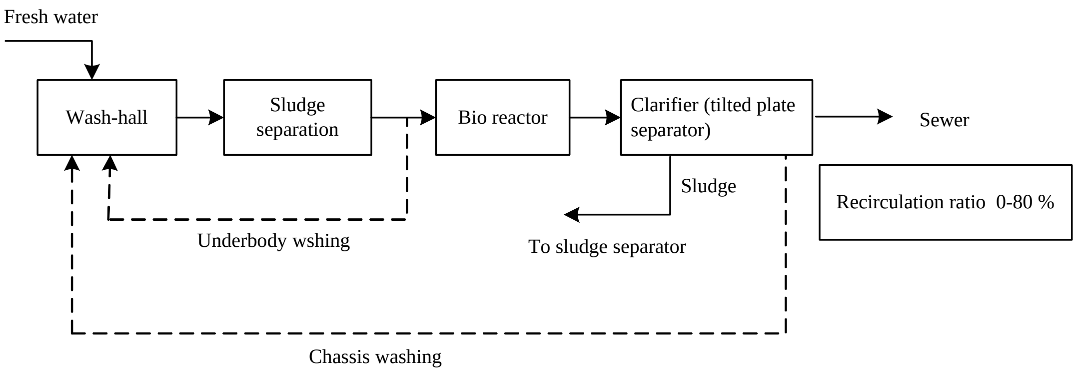
The influent water is pH adjusted (usually with sodium hydroxide) to pH 7–10. Flocculants of the same type as those used for clarifying by settling are added here as well. In addition by microflotation dispersed air, which raises the flocks formed to the surface, are added. This so called flotation sludge is dewatered in filter tanks. The filtrate is returned to the sludge separator. Sometimes the flotation sludge is treated biologically in a rod-zon plant. This is a reed bed, where bacteria degrade organic waste. The filtrate from the reed bed is returned to the sludge separator. Hydrocyclones or sand filters may also be part of the treatment system. They are often located after the oil separator in order to reduce the load of particles to the microflotation unit.

Microflotation can take considerably higher loads than settling and thus requires less space. The technique is considered to be somewhat more sensitive to interferences than chemical flocculation with settling, however.

The introduction of the technique started in the middle of the 1990´s. It is mainly used in Sweden and Denmark.

The separation of oil and metals is 8–90 % by proper maintenance and supervision (at 80 % recirculation of water). The energy use is low, < 0,5 kWh/wash. The investment is between 300 000 - 400 000 Sw. cr.

4.2.5 Biological treatment



Biological treatment uses no flocculants but instead environmental degreasing agents (alkaline water type), which is commendable. This technique utilises naturally existing bacteria to degrade organic compounds in the wastewater. This requires good aeration of the system. Sometimes nutrients are added to further optimise the working conditions of the bacteria. The biological aeration unit contains a carrier material with a very large surface. Heating of the system also favours the growth of the micro-organisms. Heated plants are rare, however, which means reduced degradation of the organic pollutants in winter, when the dirty water is cold (5–15 °C). Biological systems that recirculate the water operate at higher temperatures, which per se is positive. In winter, when salt concentrations in the water may be high, it can turn into a drawback, however.

The removal of metals is lower than that of optimised chemical flocculation plants at 80 % recirculation. In contrast, the oil concentration is very low, < 5 mg/l, since alkaline water type agents are used. (They contain no oil). Biological systems are sensitive to chemicals. Toxic chemicals may put the system out of operation altogether. If chemicals can be prevented from entering the biological plants, they work well.

If water for underbody and chassis washing is reclaimed, the recirdulation ratio is about 80 %.

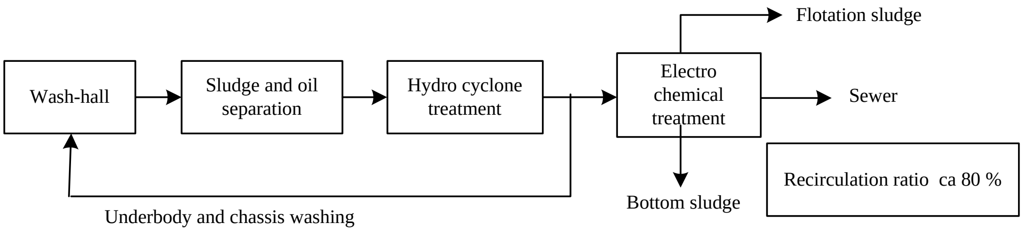
The introduction of the biological systems started in the middle of the 1990´s. Installation of these systems accelerated at the beginning of the twenty-first century. They are primarily used in Sweden and Denmark and work best in establishments with non-solvent type degreasing.
If the systems are maintained well they should be able to meet regulations by a margin.

The energy use is < 0,5 kWh/wash. If the system is heated to 25 °C the energy use is significantly increased. By how much depends on the water volume to be heated. Heating a water volume of 10 m^3 from 10 to 25 °C increases the use of energy by 175 kWh.

The investment is between 350,000 – 450,000 Sw. cr..

4.2.6 Electrochemical treatment

The system uses no flocculants, but salt is added.



This system is called electrochemical treatment and is often used at high recirculation ratios of the wastewater. Actually it is only the excess water to the sewer that is treated electrochemically, and this water stream amounts to 10–20 % of the total flow. The rest of the water is treated with more conventional gravimetric methods with sludge and oil separators and hydrocyclones.

The electrochemical treatment is essentially a flocculation and a flotation with the aid of electric current. The water enters between a cathode and an anode. The conductivity of the water is adjusted with salt to attain the correct amperage. During the electrolysis gas bubbles escape to the surface. The bubbles carry liberated aluminium (Al^{3+}) from the anode. The aluminium ions form flocks with the pollutants in the water. The flotation sludge is scraped off the surface to a separate closed tank. The treated water is pumped to the sewer, and the bottom phase is conveyed back to the gravimetric sludge/oil separator.

The advantage of this system is that no flocculants are added, just a salt, which is often sodium chloride. In winter the system is supplied with salt from road mud by the vehicles. Several examined systems have shown good treatment results. There are risks of interferences, since the dosage of salt must be controlled in an optimum way. Three fractions in contact with each other are withdrawn from the same container. One fraction rises to the surface, another with heavier particles settles to the bottom, and the treated water is withdrawn from the middle. Time control of the withdrawal is crucial for a good treatment result.

The recycling of water is normally about 80 %, when underbody and chassis washing is practised and electrochemical treatment is utilised.

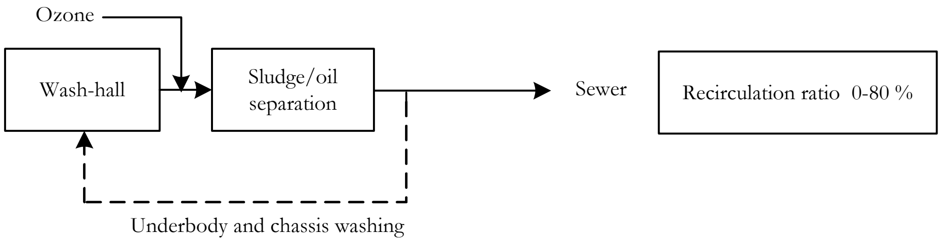
The quality of the reclaimed water for the chassis washing may be uncertain, since the main part of the water is subjected to only a simple treatment.

The introduction of these treatment systems started in the middle of the 1990´s. They are mainly used in Sweden.

The separation of oil and metals is 80–90 % (at 80 % recirculation) provided that maintenance and supervision are good. The energy use is < 0,5 kWh/wash. The investment is between 300,000 – 350,000 SEK

4.2.7 Oxidation methods

No chemicals are added.



Ozone is a very potent oxidant, which can degrade organic compounds. The aim is to decompose oil, but the tensides are also attacked. This prevents reclamation of the washing agents. The removal of metals is poor, if ozone is the only treatment used.

In a circulation system ozone may be a supplementary treatment unit to e.g. chemical flocculation. The entire system then removes metals as well. A great advantage of ozone is that it degrades micro-organisms, thus preventing odours. If an ozone treatment system is correctly installed and well maintained, the risk of staff coming into contact with ozone is very low. (Ozone decomposes very quickly). Hose-ruptures pose a risk.
There is also an oxidation method based on mechanical aeration with a turbine. The heavy oxygenation produces a certain oxidation and flotation. The pollutants are then separated from the water with a gravimetric sludge and oil separator and a particle filter.

The recirculation is about 80 %, when treated water is reused for underbody and chassis washing.

The removal of metals is not optimum, which may cause excess discharges. The technique was introduced in the middle of the 1990´s. There are a few systems installed, mainly in Sweden.

The energy use is not accurately known, but should not exceed 1 kWh/wash. The investment is between 200,000–250,000 Sw. cr.

4.2.8 Sludge and oil separator + absorbtion on cellulose fibres

Promitek AS in Norway has studied a wash- and treatment plant using cellulose fibres.
The plant was installed at Brobekk Service Centre in Oslo.

The treatment system consists of a customary sand trap with an oil separator, to which fibres are conveyed after use. Finely divided cellulose is used with washing agents in a high-pressure wash (Laserwash 4000). The aim is to replace the mechanical brush cleaning by cellulose fibres and to absorb oil and organic compounds on the cellulose fibres. The fibres shall settle in the sand trap.

Measurements were carried out in summer. The removal of organic compounds was found to be 47 % and that of oil 72 %. No measurements of metals were done. Promitec considered the water to be reusable after the fibre treatment, and the fibres to be reusable for brush cleaning.

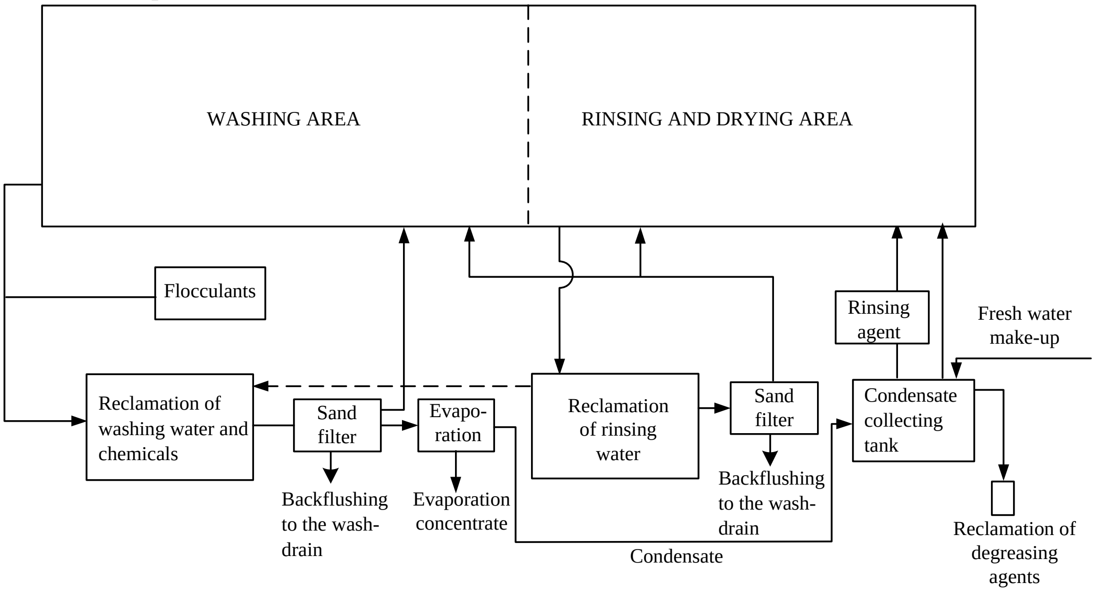
A few Laserwash plants with fibres were installed in Stockholm in the late nineties. The removal of metals was low (especially of zinc) and there were some operational problems of a technical nature, when the fibres dried. The fibres have now been removed from these plants.

Other treatment systems

The recycling of water is 0–80 % for the treatment systems described above. None of these treatment techniques rejects salts from the system. Below an account is given of a totally closed system (no water to the sewer), where salts are rejected with an evaporation technique.

4.2.9 Totally closed system featuring counter-current rinsing and evaporation

- Counter-current rinsing, sludge and oil separation, sand filtration and evaporation.



The car washing is done in a wash-hall divided into a washing area and a rinsing and drying area. The wastewater is treated in a counter-current fashion (to minimise the consumption of water at the different treatment stages). It is flocculated with orthophosphate and a polymer and conveyed to a buffer basin to settle heavier particles. The water is then reclaimed via a sand filter to the washing area, where the first washing is carried out. Water is also conveyed from the sand filter via an evaporator, where salts are rejected from the system.

Water from the rinse hall is collected in a buffer basin and pumped via a sand filter and then used as final rinse in the washing area and as first rinse in the rinsing area.

The condensate from the evaporator is collected and used for the final rinse. In the collecting tank for condensate free oil from the microemulsion (in winter) is separated from the water and reused at the degreasing stage. Fresh water is added to the system to compensate for drag-out by vehicles and ventilation. The system is "completely closed", which means that no water goes to the sewer. The evaporation concentrate is sent as waste to a central treatment plant.

The closed system now described was introduced in 2001. There are 3 plants of this kind and at a rough estimate less than 10 plants with completely closed systems in the Nordic countries as a whole.
The energy use of this system is 4–4,5 kWh/wash, of which the evaporation requires about 4 kWh/wash.

The investment cost of this treatment plant is approximately 750,000 SEK (in 2001).

4.2.10 Functioning of the treatment plants

It may generally be stated that on the whole all the described treatment systems achieve low discharges, if environmental chemicals are used and the plants are well run. Conventional sludge and oil separators without circulation of water may experience problems in constantly keeping low discharges of metals. Addition of flocculants yields high treatment efficiency even without recirculation, according to several investigations in Sweden, Denmark and Norway. Normal supervision and maintenance are still required.

A Danish report, environmental project No. 876 of the Danish EPA, certainly showed, that very low discharge values were achieved with conventional sand traps + oil separators supplemented with biological treatment and subsequent tilted-plate settling. Unfortunately the concentrations of pollutants in the influent water were not reported, nor is it possible to conclude from the report, which part of the treatment system had the best efficiency. It was an achievement of the project, that several environmentally hazardous wax products were replaced, and that the substitutes were tested at the investigated plants with good results.

The newly developed wax products should be tested in other Nordic countries as well to find out, whether or not they perform well with the stronger degreasing agents used there. In summer there should be no problems, since many car washes do not use solvent type degreasing agents.

This could also present an opportunity to test the membrane technology, which as we know has suffered from fouling problems due to the cationic tensides of the waxes.

Ozone treatment alone does not give a satisfactory treatment result. It should be part of a more extensive treatment system, where its primary function would be to keep the concentration of bacteria down, thus preventing unpleasant odours.

Biological systems have the advantage that no flocculants are added, and that water type degreasing agents are used. The systems may, however, be sensitive to interferences from undesired chemicals, which are normally not used for the vehicles in the wash-hall. This may happen, when other chemicals than the intended ones are used for washing, e.g. by the hall itself, or if vehicle owners spray their vehicles with illicit chemicals, before they drive into the hall. If such things can be prevented the systems should work well for organic compounds and somewhat less efficiently for metals. Addition of unsuitable chemicals could also interfere with other types of treatment systems, but normally not to the same degree.

Those of the Swedish guiding limits (see item 3.1.1. of table 8), which are most often exceeded, are those of zinc, and then of oil and cadmium. Sometimes the ratio BOD/COD is low too, < 0,3, which suggests the presence of compounds difficult to degrade. Do-it-yourself halls and workshops, which are connected to the treatment system of the vehicle wash, may introduce unsuitable chemicals causing a lower degradability.

The most important measures to bring about a reliable service and good treatment efficiency are the daily operation and maintenance of the plant, service agreements with suppliers and contractors, and the use of environmental chemicals

What has been said above applies to small plants, < 5,000 washes per year of passenger cars and < 1,000 washings/a of heavy vehicles. At such plants simple treatment systems are often in use, such as sludge and oil separators without circulation, but sometimes with dosing of flocculants.

To sum it up it can be stated that completely closed systems have the least impact on the environment. The disadvantage of these systems is their relatively high cost. Several investigations have shown that recirculating systems with 50–90 % recirculation ratio have significantly lower discharges than conventional systems. The conventional systems require additional investments of about 100,000–200,000 SEK to achieve the same low discharges as systems with recirculation.

The least expensive way to upgrade an existing conventional system to yield a good treatment efficiency is to dose flocculants. The additional investment in this case is about 10,000–50,000 SEK.

Regarding polishing steps for the effluent from the oil separator, there are coalescence filters, peat and bark filters, activated carbon filters and sand filters. Downstream sand filters are the most reliable devices. They also offer a good protection against shock discharges. An activated carbon filter will be costly, if the water from the oil separator carries high concentrations of organic compounds from e.g. the tensides in the dirty water, since the saturated carbon will have to be replaced frequently.

5. Water consumption

5.1 Automatic car washes

Automatic car washes for passenger cars have a water consumption to sewer of 0–500 l/washing, depending on the type of wash, the water treatment system and the recirculation ratio (0–100 %).

Without a treatment system with brush washing or brushless washing the average consumption is 200–500 l/washing.
Wash tunnels, which have a higher washing capacity, have lower water consumption, 100–250 l/washing as an average.

Recycling of water for underbody flushing reduces the water consumption by 40–50 %.

Systems with reuse of water for underbody and chassis washing reduce the water consumption by 80–90 %. The water consumption to sewer is usually 20–60 l/washing.

The table below gives a rough compilation of the average water consumption (to sewer) of systems with different degrees of closure in automatic wash-halls.

Table 10 Water consumption to sewer (l/washing), passenger cars

Without circulation	Reuse for underbody washing	Reuse for underbody and chassis washing
350	250	40

The water consumption for heavy vehicles is about 3 times higher.

5.2 Manual car washes

The water consumption with manual spray tools is between 75–300 l/washing of passenger cars and heavy vehicles.

The washing time and pressure decide the quantity of water consumed in these wash-halls. The normal actual washing time is 10–15 minutes. The washing sprayer delivers 5–20 l/minute. The lower flow refers to high-pressure flushing (~ 100 bar pressure).

The average water consumption at manual washes is usually about 75–150 l/washing for passenger cars. Washing at home presumably consumes about the same amount of water as washing in a manual wash-hall, i.e. 75–150 l/washing.

5.3 Steps to mimimise the water consumption

Reducing the water consumption is no object in itself. The important thing is to minimise the discharges of pollutants. Water is no commodity in short supply in the Nordic countries, but providing pure water and treating it in a municipal wastewater treatment plant afterwards comes with a cost. Smaller treatment plants would be adequate if the hydraulic load were to decrease due to water-saving measures in the processes.

The greatest water savings can be obtained with the counter-current technique, i.e. washing/rinsing is done starting with "used water" and then gradually with cleaner and cleaner water.

Two counter-current rinses can reduce the water demand from 500 l to 20 l and yet meet the same rinse criteria.

Reusing water for underbody flushing is a simple way of saving water. It is practised at most service stations today. The underbody flushing uses large amounts of water (200–1,200 l per passenger car). This water is collected either after the sand trap (the sludge separator) or after the oil separator. The first alternative is preferable from a cost point of view. The subsequent oil separator may then be designed for lower flows and will thus require less volume (~ half the volume).

If water is reused also for the chassis washing additional treatment equipment is usually required to guarantee a good water quality, so as not to damage the car enamel.

Total closure of the treatment system requires either reverse osmosis (RO) or evaporation to reject salts from the system. These treatment units can work as kidneys in the system. Salts will of course also be disposed of when the system is emptied and filled up with fresh water. The kidney units can prolong the intervals between the sludge collections.

The degree of water circulation and the level of ambition may sometimes depend on the cost of water. This cost varies greatly between the municipalities and districts in the Nordic countries (0-35 SEK/m^3). On the Faeroe Islands water has up to now been free of charge.

For manual washing in wash-halls reclaimed water may be used as well. The risks in the working environment are then somewhat greater, since manual high-pressure sprayers are used. The aerosol mist contains detergent components but may also contain bacteria. Some kind of protective equipment is to be recommended, if work is going on for longer periods.

6. Risks

The following factors may to a varying degree have an influence on the discharge situation.

- Operation and maintenance. This is probably the most important function to minimise the risk of excessive discharges
- Pump breakdown
- Emergency overflow
- Use of environmentally hazardous chemicals, e.g. solvent type degreesing agents, such as white spirit or nonylphenol, microemulsions.
- Cleaning of the hall itself with other detergents than those used to wash the cars.
- Preapplication of solvent type detergents in connection with the wash-hall.
- Inferior water treatment equipment.
- Inadequate sludge collection procedures, something which may cause excessive discharges.
- Washing when sludge is removed from the system may cause highly excessive discharges.
- Incorrect pH of the water. At low pH-values ($pH < 6$) metal discharges increase.
- Too high hydraulic load on the existing treatment system (too much water is being used).
- By-pass of the treatment system in case of minor functional troubles and turning on fresh water.
- Choice of engineering materials in the wash-hall and for the washer and the treatment plant. The materials must withstand the washing liquids, or else there is a risk of dissolution of metals and components of plastic materials.
- Use of microemulsions where gravimetric sludge and oil separators without flocculant-dosing are installed. The oil is mixed with water and has no time to self-separate in the system, something which leads to excessive discharges.
- Surface water enters the treatment system. This may cause overload and with that excessive discharges.
- High concentrations of salt in the system may cause corrosion damages, above all in winter. This is counter-checked with addition of corrosion inhibitors or rejection of salts from the system.
- Chemicals are not stored in a safe way.
- High-pressure washing produces considerably more aerosol mist than brush washing, which causes higher emissions to air.

- Volatile solvents cause emissions to air.
- Odour: Stagnant water favours anaerobic conditions, which results in unpleasant odours, oft from hydrogen sulphide (”rotten eggs”). Solvents may also give rise to odours.
- Noise: Fans and drying and ventilation equipment may be misplaced, misdesigned or have defective sound insulation, things which cause noise problems in the surroundings.
- Washing outside the wash-hall: Washing at home or in similar places poses a risk to the environment, unless environmental agents are used. There is a risk of polluting the ground water, if the site is not connected to the municipal sewer system.

6.1 Minimising risks

The following measures diminish the risks of excessive discharges:

- Self-supervision and good management and maintenance of the treatment equipment are the most important measures to prevent unintentional discharges.
- Containers for chemicals shall be kept under roof. The protective embankment shall be able to hold the volume of the largest tank + 10 % of the volume of the other containers in case of a breakdown. The material of the embankment must withstand the chemicals in use.
- When pipes or containers in ground are replaced, try to prevent leakage from the old system. An unusually high water consumption may also be an indication that there is a leakage.
- Alarms at pumps, at level monitors in tanks for chemicals and when pH-values fall above or below present limits are definitely advantageous. The alarms make it possible to take immediate measures in case of trouble.
- Level monitors can be installed in emergency overflows. Alternatively these overflows can be plugged
- Avoid preapplication of detergents before the vehicle is driven into the wash-hall.
- Never wash vehicles when sludge is removed. That may cause heavy and excessive discharges.
- Avoid by-passing the water treatment system with fresh water in case of operational troubles.
- Do not use microemulsions if there is only a gravimetric sludge/oil separator.
- Instruct the staff and point out the essentials how to avoid unintentional discharges.

7. Operation and maintenance

As was mentioned earlier the management and maintenance of the water treatment equipment is the most important factor to keep the emissions of pollutants as low as possible.

Self-supervision with journal-keeping and well established routines facilitate the work. Some checks are made daily and others at longer intervals. A possible working schedule could look as follows:

Daily checks

- Visual check of the effluent water and a smell-check on the premises.
- Record any operational troubles.
- Check the detergents, the flocculants and the pH-adjustment chemicals. Have they been topped-up and is the dosing equipment working?
- Check the aerators of the biological treatment.
- Check the current in the electrolytic splitting.
- Check the levels in buffer tanks.
- Other checks depending on the treatment technique.

Weekly checks

- Consumption of water and chemicals and the number of washed vehicles.
- Check the alarm functions.
- Check the sludge level in the sand trap and the oil separator (can be done at longer intervals depending on the season and the volumes of the system).
- Check the sand filter (backflush function etc.).
- Calibrate (any) pH and conductivity meters.
- Clean the wash-hall and washing machines as required.

Monthly checks

- The same as the weekly checks.
- Check alarms, dosing equipment, level monitors etc.
- Compile records of the consumption of water and chemicals and the number of washed vehicles.
- There may be a service agreement that the treatment-plant contractor shall go over the plant at regular intervals and brief the staff about new developments.

Once a year

- Compile the records of consumed commodities, number of washed vehicles, any operational troubles and of other specific data on the treatment plant. The operational availability of the plant is important. If the availability is close to 100 %, this indicates that there has been little trouble with the treatment plant.

Sampling

Samples are taken from the effluent water. The selected sampling point shall be turbulent, so that the sampled water is well mixed. For the self-supervision random samples are collected and visually checked for turbidity. The pH-value can also be determined easily.

For more extensive functional tests automatic samplers are used. They should preferably be flow-proportional, but timer-controlled samplers can be set to sample only when vehicles are washed. They will then provide a form of proportional sampling.

The functional test is done by an external expert. The samples are analysed at an accredited laboratory.

Sampling should be done in winter when the load is at its peak, and it shall be done between sludge removals. It must not be done immediately after removal of sludge, since the system has then just been filled up with clean water.

8. Recommendations

8.1 General considerations

We will recommend measures that if implemented could result in the future best available technology (BAT) to reduce the environmental impact from vehicle washes at reasonable costs.

It is of course important that the future treatment systems are efficient enough to significantly reduce the load of pollutants from the vehicle washes on the municipal wastewater treatment plants. If the majority of the pollution sources can be minimised it may be possible to obtain municipal sludges pure enough to be used in agriculture and forestry to a greater extent than today.

Most vehicles are washed in urban aeras, where the sewage system is well developed. Too many vehicles are still washed outside wash-halls, however, without any kind of wastewater treatment. About 50 % of all vehicle washings are carried without acceptable wastewater treatment.

The goal must be to get many more vehicles to the car washes. The wash-hall proprietors will then have a strong incentive to build more washes with good treatment systems. If the number of washings increases, the cost per car will go down. In order to minimise the discharges of pollutants at a reasonable cost the vehicle washes could be classified into different categories. In urban aeras, where most of the vehicles are stationed, the classification could be done according to the number of washings. This classification will then decide the type of treatment system.

For small car washes with few vehicle washings, including establishments in rural aeras, less stringent treatment requirements should be necessary. However, local conditions, such as a high load on the municipal wastewater treatment plant or sensitive receiving waters, must finally decide.

Below we formulate a proposal for such a classification.

8.2 Population centres

8.2.1 Automatic washes (>15 000 passenger-car washings and >3,000 bus/lorry washings) per annum.

- Earlier investigations have shown, that reuse of water reduces the discharges of both oil and metals. Introduction of advanced water treatment systems with water reclamation at the big car washes would result in substantially reduced discharges. In conclusion, big automatic car washes should have supplementary treatment equipment besides sand traps and oil separators. The volume of wastewater from the treatment plant should be maximally 50 l for passenger cars and 150 l for lorries/buses in order to minimise the discharges to a great extent. The latter figure is based on a standard length of 12 m. For other lengths the volume is recalculated proportionally. A 24-m bus/truck with trailer may then discharge 300 l of wastewater. Refilling the system with fresh water and dilution of detergents to solutions ready for use are exempted.

- With good management the discharge values will be below the guidelines formulated by the Nordic Ecolabelling (see 4.1.1. table 1).
- Recently built halls and installed washing machines as well as treatment plants should be constructed of corrosion-resistant materials.
- Hall gates, washing machines, ventilators and similar equipment should have drip-mouldings or be designed in such a way that dripping to the vehicles is minimised.
- Environmentally suitable chemicals shall be used. Alkaline water-type degreasing agents or shampoos are preferable from an environmental point of view. Microemulsions yield a better washing result against splashes of asphalt, thus it should be acceptable to use them, provided that the solvent content is not above 10 % and of the low-aromatic type (< 0,5 % aromatic hydrocarbons in the concentrate).
- No solvent-type degreasing agents should be used for six months of the year, e.g. April/May – September/October.
- Investigate the possibilities to shut down the drier in summer. That should save energy.
- Investigate the possibilities to exclude the wax products. They give a limited protection anyway. It would be better to have separate waxing plants, which would offer the cars a better protection. If the waxes are removed from the wash-halls, it may be possible to introduce membrane technology.
- Unannounced sampling drives in the surface-treatment industry of Sweden have contributed to substantially minimised discharges. Such drives at vehicle washes could give similar results.
- Management and maintenance are very important to the functioning of the treatment plants. This is controlled with alarms, self-supervision and a clear assignment of responsibilities.
- The records shall comprise the number of vehicles washed and the consumption of water and chemicals. Sludge collections are recorded as annual number and quantity, haulage contractor and consignee of the sludge. Any breakdown is also recorded. The records are compiled and the compilations are sent to the environmental authorities once a year.

- A representative sampling of the effluent water is done at least once a year, in winter when the load of pollutants is high. The sampling must not be carried out immediately after a sludge removal, when the system has been filled up with fresh water.
- In case of more severe breakdowns or operational interferences causing a heavily impaired treatment efficiency the vehicle wash should be automatically stopped until the cause has been attended to.
- Arrange information drives, e.g. that it is prohibited to bring your own degreasing agents and apply them in advance because of the risk of trouble in the water treatment plant. In so called “do-it-yourself” (DIY) halls the same prohibition applies. The proprietors of such halls must provide environmental detergents.
- If environmental detergents are preapplied at the wash-hall, collecting sinks shall be connected to the treatment plant, and a screen roof should be put up.
- Surface water must not enter the treatment system, since that will increase the hydraulic load and thus impair the efficiency of the treatment plant.
- Relevant analytical parameters are pH, oil (aliphatic hydrocarbons), cadmium, lead, copper, and zinc. The parameters chromium and nickel, which are included in the Nordic Ecolabelling (the Swan), may be excluded, since the concentrations are low and the metals are not as toxic as cadmium and lead. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) should also be measured to get an assessment of the biodegradability. If phosphorus–containing compounds are used, phosphorus should be analysed as well. Whether the plasticizer diethyl hexylphtalate (DEHP) should be included, as suggested in Denmark, or not must be decided when more information is available.

8.2.2 Closed system, automatic system >15 000 passenger cars and >3,000 buses/lorries per annum

If the treatment system is closed, stronger detergents can be used. The decreasing agents could contain solvents low in aromatic hydrocarbons, since there is no effluent to the sewer.
Such degreasing programmes could possibly be used all the year round.

- The issues described under 8.2.1. are as a whole applicable here too.

8.2.3 Automatic or manual car washes. 5,000–15,000 passenger cars – and 1,000–3,000 buses/lorries per annum.

- Sand traps and oil separators according to EU standards should be installed. Where úndérbody washing is done, reclaimed water should be used. If wastewater is discharged to a heavily loaded municipal treatment plant or to sensitive receiving waters reclaimed water should be used also for washing chassis. This requires additional treatment equipment.

- If microemulsions are used the treatment plant should be supplemented with splitting agents or biological treatment to meet the guideline of 50–100 mg/l for oil.
- What has been said about larger systems is applicable here too, i.e. the same discharge levels of pollutants per vehicle (see 3.1.1 table 8).

8.2.4 Washing in wash-hall <5,000 passenger cars and <1,000 buses/lorries per annum.

- Environmental chemicals, sand traps and oil separators according to EU standards.
- Reclamation of water is not required.
- The discharged quantities of pollutants per vehicle should be about the same as those in section 8.2.3.

8.2.5 Manual washing at home etc.

- Inform the general public that cars should preferably be washed in wash-halls to minimise the risks of environmental pollution.
- Environmentally suitable chemicals shall be used.
- The wastewater shall as far as possible be conveyed to the municipal sewage system or to a private seepage system, if there is such a system.

8.3 Thinly populated areas

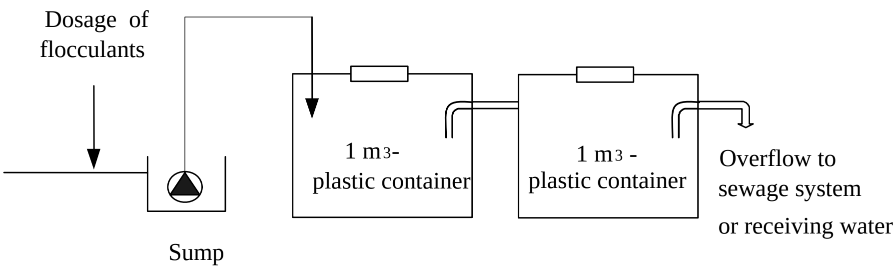
8.3.1 Washing in a wash-hall in thinly populated areas

- For car washes with > 5,000 passenger cars and > 1,000 buses/lorries per annum the requirements should be the same as in population centres.Car washes with < 5,000 passenger cars and < 1,000 buses/-lorries per annum shall have sludge and oil separators. Somewhat higher discharge levels may be tolerated, however. Each individual municipality must decide what is required depending on the receiving waters.
- If there already is a sludge/oil separator the discharges of pollutants can be further reduced by simple means. Installation of two small dosage pumps, that dose flocculants and pH-adjustment chemicals (alkali) to the influent water to the sludge/oil separator, is all that is required. The dosing is done when vehicles are being washed. The

additional cost will be 5,000 – 6,000 SEK A certain amount of maintenance is required, however.

8.3.2 Manual washing at home etc.

- The same considerations as in population centres apply.
- An oil separator may be constructed from two plastic containers of about 1 m^3 each. They are connected with bent pipes, which reach down below the surface of the liquid. The containers with the pipes will work as an oil separator. A small sump of 50-100 l is cast or dug if the separator is built outdoors. The wash-floor should have a roof to keep rainwater out. Three pumps are necessary, one to pump the water to the plastic containers, and two dosage pumps for flocculants and pH-adjustment chemicals. The flocculant can be a combination of aluminium salts + polymer or orthophosphate + polymer. These chemicals together with the alkali split the oil emulsion and make the metals settle (see the outline sketch below).



Outline sketch. Simple flocculation and settling plant for vehicle washing.

Another conceivable and simpler solution is to install a bark filter in a surface-water or wastewater sink.(Färm 2003). This could also be done with an mobile system.

8.4. Future technologies

The closed system described in section 4.2.9 is based on a design with washing and drying in two halls. It should be technically possible to fit this technology into one hall, which would reduce the costs considerably.

The tensides used in vehicle washing should be modified to give less stable micro emulsions. That will give smaller and cheaper treatment systems. The requirement is of course that the washing result is as good as earlier.

If waxes can be replaced by some similar protective layer, which is not cationic and which is compatible with other detergents, water treatment will be facilitated. This has been tested with a good result in Denmark, however not with solvent-type degreasing agents. If the waxes are replaced, the membrane technology will be a viable option because of its high capacity, which means smaller and cheaper plants. Reverse osmosis (RO) filtration is the membrane technology that rejects salts from the system.

If the painted surface of the vehicle can designed to repell dirt better than today, this will also give be environmentally beneficial.

9. Glossary

Alkaline degreasing	Sodium meta-silicate, potassium or sodium hydroxide, 5-20 %, tensides 5-10 %, complexing agents (usually NTA) and water
BAT	Best available techniques
DEHP	Diethyl hexylphtalate is a plasticizer used in underbody coating, among other applications.
Emulsion	Emulsions are formed when petroleum products are finely dispersed to a stable solution with the aid of tensides
Cold-degreasing agents	Solvents that contain petroleum hydrocarbons (like white (petroleum) spirit) + 2-4 % tensides. Cold-degreasing agents may contain aromatic hydrocarbons. Ordinary white spirit contains about 20 % aromatic hydrocarbons, highly aromatic white spirit > 80 % and dearomatised < 0,5 % aromatic hydrocarbons. Cold-degreasing agents are considered environmentally hazardous, since aromatic hydrocarbons are difficult to degrade, toxic to water-living organisms and potentially bioaccumulating (they have a tendency to accumulate in organisms)
Flocculants	Salts (e.g. aluminium chloride/sulphate + polymer or orthophosphate + polymer) used to split oil emulsions or to form larger flocks with good settling properties.
Coalescence filter	A coalescence filter has a somewhat better capacity to separate dispersed oil than a conventional gravimetric oil separator. When the liquid passes through the filter the small oil droplets of the dispersed oil are absorbed and form larger drops, which rise to the surface.
Complexing (sequestering, chelating) agents	The most frequently used complexing agent for car washing is NTA. It is a water softener, which forms complexes with calcium and magnesium ions. This improves the washing efficiency of the tensides.
MICROTOX	Method to assess the toxicity of compounds in aqueous solution. Very briefly the method is based on the inhibition of the light-emitting capacity of a certain bacterium.
Microemulsion	Cold-degreasing agent with a lower content of petroleum hydrocarbons (white spirit), 5 - 30 %, which are emulsified with 5 – 20 % tensides and water.
Nitrification test	Inhibition of the capacity of micro-organisms to oxidise ammonia to nitrate.
NTA	Nitrilo triacetate. This complexing agent is considered easily biodegradable and moderately or little toxic to water-living organisms.
OS	Oil separator (gravimetric)
PAH	Polycyclic aromatic hydrocarbons. They may be found e.g. in tyres.
RO	Reverse Osmosis is a filtration technique. Its most widely known application is to produce drinking-water.
Shampoo	The main constituents are tensides and water.
ST	Sand trap or sludge separator
Closed system	No effluent from the vehicle wash is connected to a sewage disposal system.
Tensides	Tensides are a group of surfactants with cleaning properties.

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Additional remarks

We have been in contact with several suppliers of car washes and of water treatment systems for vehicle washes, among them Autowash, Kärcher, MCP Vattenrening, Kleindienst - California, ReClean, Revatec Kambre, Tammermatic, Wash & Circulation Scandinavia System, Washtec and Westmatic.

Use e.g the search engine Google and search for oil separator + washing + car or “oljeavskiljare + fordonstvätt”, and you will find a lot of articles on the subject.

Websites

The following websites give information about vehicle washes.

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DHI Water and Environment, http://projects.dhi.dk/bilvaskehaller/
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Appendix 1.

A Summary of "Guidelines for vehicle facilities in Stockholm"

In Stockholm there are two alternatives for emissions from vehicle facities. (Table 1 and Table 2)

Table 1 Alternative 1, Emissions, at least 80 % recirculation

Analyses	Private car	Lorry, bus or other heavy vehicles
Σ Pb, Cr, Ni	10 mg/fordon	30 mg/fordon
Cd	0,25 mg/fordon	0,75 mg/fordon
Zn	50 mg/fordon	150 mg/fordon
Oil	5 g/fordon	15 g/fordon

In the alternative 2 (table 2) where no recirculation is needed have the requirements been intensified

Table 2 Alternative 2, Emissions without recirculation.

Analyses	Private car	Lorry, bus or other heavy vehicles
Σ Pb, Cr, Ni	5 mg/fordon	15 mg/fordon
Cd	0,10 mg/fordon	0,30 mg/fordon
Zn	50 mg/fordon	150 mg/fordon
Oil	2,5 g/fordon	7,5 g/fordon