International Journal of Water Resources and Environmental Sciences 2(1): 13-19, 2013
ISSN 2311-2492

DOI: 10.5829/idosi.ijwres.2013.2.1.1126

A Review of Waste Water Treatment in Antarctica

Naba Kishore Pradhan

Ispat College, Rourkela, Odisha, India

Abstract: Today more and more of our focus in Antarctica and the rest of the world are turning towards how we, theinhabitants, leave footprints on our planet. Scientists have found trace of humans all over the world evenin Antarctica's fauna and flora. To be able to do research and understand our planet's development andproblems, we must try to make as small impact on Antarctica as possible today and leave a pristinecontinent to the coming generations. One way to manage this is to not release untreated waste water.The aim of article was to investigate different techniques for cleaning grey water for the Swedish Antarctic Summer Station Wasa. A survey on waste water treatment on almost all Antarctic researchstations has been carried out in order to find a suitable treatment method for the grey water released from Wasa.The most common treatment method at the permanent stations are biological treatment (8 stations) followed bysecondary treatment and maceration (4 stations per method). The results are based upon analyses from then survey answers and information from COMNAP's homepage about members' stations.

Key words: Waste water · Treatment · Antarctica · Survey system

INTRODUCTION

The Antarctica is the coldest, driest, highest and windiest continent on earth. With an average height of 2500 meters, it is the highest elevated continent and that is more than three times higherthan most continents. It is also the most isolated continent, surrounded by stormy oceans. Itcovers an area twice the size of Australia [1]. It contains a surprising number and variety of lakes, ponds and pools. Almost every lake here has arisen as a consequence of glacial retreat, thoughearth movements have formed a few [2]. Since most part of the continent is situated below the 70°S,the sun shines 24 hours per day during the austral summer and it is totally dark during the winter.Since Antarctica is in the southern hemisphere their warmest period is during our winter and their coldest is during our summer. In Antarctica there is a corresponding phenomenon to our Northern Lights the Southern Lights. It is the solar wind and the earth's magnetic field that causes thisphenomenon. Roughly 98 percent of the surface is covered with ice7 and it contains nearly 70 percent of theworld's fresh water resources. The thickest ice found is in Wilkes Land near the magnetic SouthPole, where it reaches a depth of 4776 meters. If all the ice dissolves it would increase the oceanlevel with almost 76 meters. Because ice reflects more than 80 percent of the incoming radiation, this is one of the several explanations why it is so cold on the continent. It is the two percent notcovered with ice that are the most important environment for flora and fauna in Antarctica. Theflora that is found on bare ground can be hundreds years old and grows extremely slow. Becauseof this, all contact that could harm the flora should be avoided.

Historical Background to Antarctica: The conception "Terra Australis Incognita"- an unknown continent in the south- was already alive during the antiques approximately in year 500 B. C. Even the Greek antique philosophersfor example Aristotle's understood that the world was spherical. They predicted that there had tobe an opposite pole to Arctic. The first known expeditions to Arctic took place about 150 B.Cwith Ptolemaios. Many were the following attempts to discover the South Pole continent. Thefamous explorer James Cook crossed the Antarctic Circle in 1773, but did not come across acontinent. But he did discover a rich animal life existing of seals and whales, which started ahuge commercial hunt in the area. Even though three different expeditions claimed to have foundAntarctica in the 1820s, the land was still a "terra incognito" [3].

Corresponding Author: Naba Kishore Pradhan, Ispat College, Rourkela, Odisha, India.

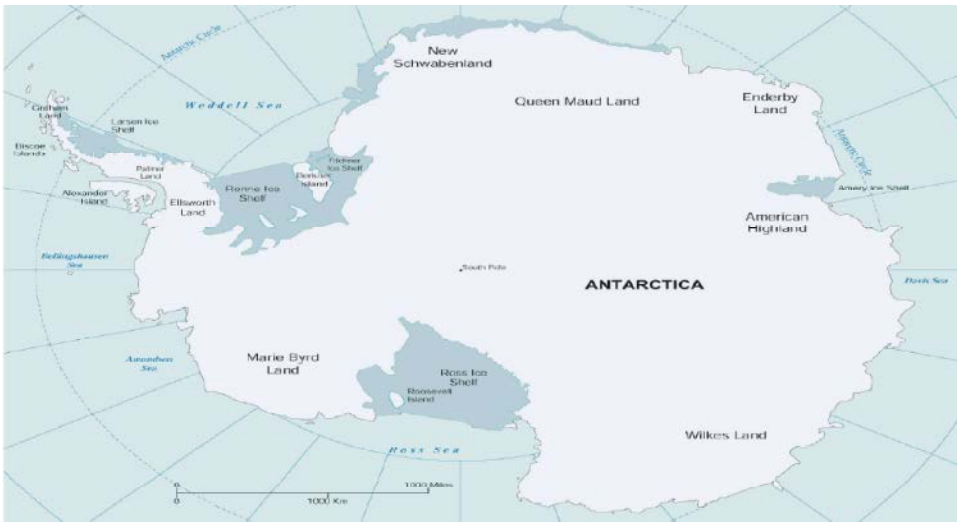

Fig. 1: Map . Antarctica

The number of expeditions to the South Pole exploded in the end of the 19th century. To be partof a polar expedition was full of prestige and different geographical societies competed for thegovernments founding's for their expeditions. The ones that made it all the way back home werecelebrated as heroes [4].

Waste Management: Annex III to the Protocol on Environmental Protection is about waste disposal and wastemanagement. It is stated in article 1:2 that the amount of waste produced or disposed of in the Antarctic Treaty area shall be reduced as far as practicable to minimise interference with natural values of Antarctica, with the scientific research and other users of Antarctica consistent to theAntarctic Treaty. In article 1:3 it is stated that waste storage, disposal and removal from theAntarctic Treaty area, but also recycling and source reduction shall be an essential considerationin the planning and conduct of activities here. In the fifth paragraph in article 1 it is stated thatpast and present waste disposal on land and abandoned work sites, should be cleaned up by thegenerator of such waste and the user of such sites. Exceptions are historical sites or monumentsor in those cases where cleaning up will give or could give greater adverse environmental impactthan leaving its existing location. In article 5:1b it is stated that sewage and domestic liquids(shower-, kitchen- and washing waste water and urine) generated in stations where the averageweekly occupancy over the austral summer is approximately 30 individuals or more should usetreatment on the water with at least maceration before it is released into sea.

Fig. 2: Picture A Krill.

Aims and Scope: The objective of this article is to find a treatment method for the grey water from Wasa. The work is focusing on finding a method that can work in the extreme conditions and harsh climatewith low temperature. Another aspect is that the station only is used during the austral summerand therefore the system must have the feature that it can be stopped and started with shortnotice. The system should preferably not need power or at least need very little power. Becauseof the location, the system should not need maintenance very often and not need surveillance bystaff on the station. The aim of this report is to find a system that is optimal in terms of emissions,efficiency, cost, size, life and maintenance.

Human impact on Antarctica: As mentioned earlier the extreme climate and small variety of available food makes the wildlifein Antarctica especially sensitive to environmental hazards. Today researchers are not the onlyvisitors in Antarctica. During the last season 2003/04 approximately 27 50024 tourists went there.Both researchers and tourists increase the risk that humans introduce infectious agents that arenew to the Antarctic

flora and fauna. Already micro organisms with origin from humans havebeen detected around Antarctic stations. Some of those were found on species and the microorganisms have potential to cause devastating effect on native fauna. Contaminated food anduntreated sewage from research stations, tourist and commercial ships are the most likely factorsfor introduction of pathogenic bacteria and virus. In spite of the low water temperature thesebacteria can survive in the marine environment during a long time, where it can be transferred toseabirds and marine mammals. Bacteria can also travel a long way from its outcome and posepotential dangerous to organism very far away25. There have been some reports of mass mortalityin the area, suspected to be caused by infectious diseases in seal and bird population. One was atScott Base on Ross Island in 1990-1991 were an incident with unintended pollution by sewagehad consequences on marine fauna in the affected area with a high mortality of marine animalspecies. In 1998 on Auckland Island both Salmonella and a Campylobacter-like bacterium causea suspected sequence of mass mortality in sea lions.

Swedish Polar Research in Antarctica: The Swedish Antarctic Research Programme (SWEDARP) started in 1987/88 and a smallresearch station, Svea was built in Dronning Maud Land. The following season a larger station,Wasa, was constructed on a nunnatak 200 km away from Svea. Since then there has beenexpeditions almost yearly. 34The Swedish Polar Research Secretariat was founded in 1984. The purpose of this governmentagency is to promote and organise Swedish polar research and activities. The secretariats task areto give access to the Artic and Antarctica for Swedish scientists and maintain the researchstations Wasa and Svea in Antarctica.[5]

Grey Water: All waste water produced on a station except toilet waste (urine and faeces) is called grey water.The largest part of residential grey water comes from laundry, showers, sinks and washing dishes. The amount of grey water produced per day and person varies from 20- 30 litres in poorregions and up till several hundred litres in rich parts of the world. To get the grasps of thefigures an ordinary bathtub contains approximately 300 litres [6, 7].

Characteristic ingredients in grey water are fat, oil and other organic substances from cooking,residues from soap and tensides (tensid = surfactant) from detergents. This all reflects thelifestyle in the household and the choice of chemicals used during washing-up, laundry and in theshower.

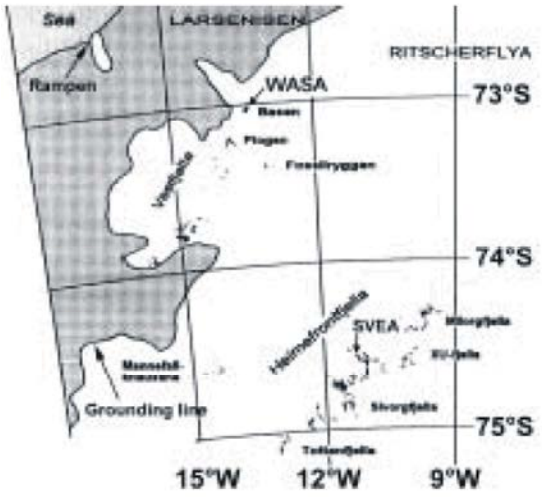

Fig. 3 :Map over DronningMauds Land.

The content of pathogens in grey water is generally low, because pathogens are primarily addedto waste water through faeces. Still grey water can be seen as a health hazard and that is mainlybecause of all the indicator bacteria that are found in grey water. This could be explained by verylittle amount of bacteria in grey water increase due to its contents of easily degradable organiccompounds.[8] It has been shown that grey water can contain pathogens especially bath/showerand laundry water can have low content of pathogens, bacteria and virus. Particularly laundry andbath/shower water from infants and sick older people.48Metals in grey water come from different leaching sources in dishes and laundry, such articles arecutlery and pots in the dishes and metal buttons, zips and textile colours in laundry. It could alsocome from leaching from pipes, wires, machines and similar products.49The levels of nutrients in grey water are normally low compared with normal waste water (greywater and toilet waste) from water-borne systems. In some grey water high concentration ofPhosphorous are found. This originates from washing and dishwashing powder, where it is usedfor softening the water. There are products with out Phosphorous on the market, which works asgood as the one with Phosphorous.

One way to get cleaner and less dangerous grey water starts with investigating what is put in tothe system. This can be done by looking over all chemicals used in the system, seeing if theycould be changed to more environmental friendly ones.50Today more and more of our efforts are focused on green electricity, environment friendly food,renewable fuel and sorting garbage. But at the same time the number of cosmetics are

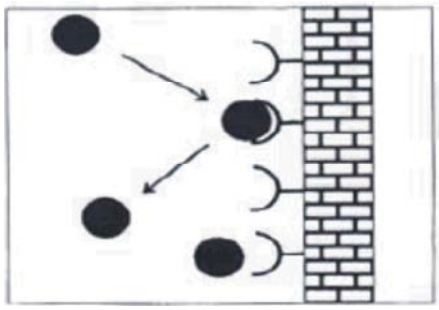

Fig. 4: Description on Adsorption

increasingand we use more than before. It has been shown that this cosmetics and indeed hair productscontains dangerous and environment hazards. Many substances that are forbidden in otherconsistencies exist in hair products. In one investigation carried out in Stockholm they found thatin 73 examined products they found 438 different compounds and 21 of them were considered orclassified as dangerous for the environment. Further 41 could be harmful for the environment andthen pigment was not included. Many of the products in the investigation contained severalsubstances with the same qualities but with different toxicity for the environment. 51Triclosan is a chemical used for its antibacterial properties in many detergents, dish-washing liquids, soaps, deodorants, cosmetics, lotions, anti-microbial creams, various toothpastes and anadditive in various plastics and textiles. It has been showed that it does not break down in purification plants and becomes bio accumulated in fish. It is classified as a toxic substance thatimmediate kills water living organisms and can give difficult long time harm in the water environment. It can also transform into dioxins by combustion. If Triclosan is added in chemicotechnicalproducts it must to have a warning text, but it is not needed for cosmetics. Even thoughtwo tones a year is let out only in Sweden.

MATERIALS AND METHODS

There are several different treatment methods for grey water. The first thing to consider when trying to find a treatment method is to know the characteristics of the water that should betreated. If the toxic substances in the grey water are identified, the next step is to see where theyoriginate. Sometimes it can be a derivate from a reaction that started after the actual reaction. There is always a possibility to replace the raw material that contains the toxic substances. If it isnot possible to replace the raw material then it is time to find a treatment method.When all the background data is complete, that process starts. There are at least two main watertreatment methods. The most common is external treatment and it is used outside the productionspot. Another frequent title for the external treatment is the end of pipe solution. The secondmethod is internal treatment and that it is supposed to be treatment on the source directly. Boththese techniques are common in industrial use. Today the development goes towards having moreinternal treatment, though it is easier to deal with one pollutant at a time. Together with theexternal technique you will get a complete treatment for various pollutions and to a reasonablecost. It is also good to have different techniques in a plant to get better cleaning, but also to get amore fail safe system. Because if something happens when there is only one treatment method itis common that the water passes by without treatment and that can be devastating for thesurroundings of the outflow [8-12].

Adsorption: With adsorption unwanted molecules can be separated from a liquid by getting caught on asurface of a solid material, the adsorption-material. In figure 4.1 the getting caught process forthe unwanted molecules can be seen. All material used as an adsorption-material has a big inner surface. Activated Carbon is the most common one. It has a big specific surface, 500 to 1500m2/g, which explains the good adsorption quality. It can remove organic substances from waterand is best used on substances with low solubility in water, high molecular weight and lowpolarity. The concentration of substances to be adsorbed should not exceed 1 %. This process isalso favoured by low temperature. It is also possible to use polymeric adsorption-material and canbe tailor-made to fit the substances with different solubility and polarity. It is a suitable method toremove biological, hard to break down, organic substances from waste water, especially whenother methods cannot be used. Often used as a polish method before the treated water is let out toget really clean water [13].

DISCUSSION

It seems like many countries goes around the requirements of the Environmental Protocol by having stations occupied by less than 30 individuals per week during the austral summer. By thisstandard, even a permanent occupied station fulfils the Antarctic Treaty without having any watertreatment. Even if there is an article69 in the protocol saying that if there are less than 30 personsa week during the austral summer you do not need to have treatment, every country should or atleast

could act to prevent releases of sewage that can cause danger for the surroundingenvironment. Also, there seems to be a big difference between how tourists and stations aretreated. According to Olsens 70 investigation it seems like the tourists manage to look after themself's. On the other hand the personnel at the stations stay in Antarctica for much longer time andhas at least until now not been so considerate about the surrounding environment. But thepersonnel at the stations have been in Antarctica for longer than tourists and that gives longertime to build up the damages. In the earlier days the effect that humans can give on the flora andfauna was not know and researched. Today we know much more than before and can take moreresponsibility for our actions [14,15].

Much seems to be changing, but perhaps it is time to force all permanent stations to use some kind of water treatment and stop the leak of potential hazards to the marine life. For example ifyou have a permanent station with an average of 25 people their individual water use is 100 litresper day and in a year that will give a total water use of 9,125,000 litres leaking right out in theocean. If there is a summer station open for 3 months and the same water use and same occupation, it gives 225,000 litres that leaks out. The permanent stations water leak is over 40 times bigger and during a whole year. The big differences for the environment when it comes towater leak and disturbance is that for a summer station there is almost 3 times more time to recover from the visit, but with a permanent station there is never time for the environment to recover. All countries with stations doing research in Antarctic need to have the environment as pristine aspossible. Then, not to have a working treatment of waste water seems really bizarre. It wouldprobably be better if there were no trace of humans in the environment and in that way easier toget good results or better predictions of the future. Antarctica is the last unexplored part of earthand our use of it should not be devastating for the next generations' research.Also, the expression "station" is used for both places like Wasa and for McMurdo, the Americanbase that can occupy more than 1000 persons during summertime. It seems like there should bedifferent rules for small stations and really big stations, looking more like small villages. It wouldbe a better rule, if it were more concrete and separate summer stations from permanent stations,but still consider how many residents the stations have. It would be preferable that if a stationuses more than say 3 m3 water a day it must have a treatment system.their treatment plant 2003 and had prior to that no treatment of their waste water. In this case itfollows that waste water from at least 1000 persons has been released right out to the oceanduring earlier summer seasons. It could have devastating effects on the marine life in McMurdoSound. Untreated water has been released during a long time and probably the consequences ofthis will come throughout a long period of time. Since the affects are not really investigated, it isbetter to prevent damages than to wait and see what happens.One way to prevent damages from untreated waste water is to find out what is put in to the system [16-20] All products used with water ends up in the outgoing water. If the products used atstations are too checked and selected after environmental friendliness, some of the harm can beprevented. An example can be that the station's owner makes a list of products that are approvedfor use in Antarctica. Products that contain triclosan, for example toothpaste and soap, should notbe used at all and especially not in Antarctica. The already sensitive ecosystem in Antarcticashould be treated carefully and not be exposed to unnecessary potential danger. As Johansson's71study showed cosmetics and hair products contains dangerous and environmental hazards. Thesecond best way to prevent the flora and fauna in Antarctica from potential hazards is to choosegood products to bring. This must be the easiest way for all countries to be more environmentalfriendly in Antarctica, because all the products are brought there.

Researchers today find more and more indication that impacts from human activities affects theflora and fauna. Our knowledge also change our preferences when it comes to see what productsare dangerous both for us but also for the environment. The development provided that something that was not considered dangerous 30 years back is that today. This shows that it isnot only the products used at the moment that are a problem but also those we used 50-60 yearsback that cause problems today. The environment suffers a great longer time from our mistakesthan we do, because the trace can be seen during so long time [21-23].

Conducting the survey was much easier then to get information from potential companies abouttheir small treatment plants. Even though the companies were contacted several times they didnot answer. A few answers were received, but one of the companies had a really good solution.The Emendo solution may not be the absolute best, but with their staff, the overall achievement isthe best. It is important to have both good technical solutions and also have employees that arepushing to do better and willing to develop during the process [23-26].

The method in the plant that is recommended is one with chemical precipitation andsedimentation of organic material. It is an easy process that works the same way all

the time andthe chemicals are added after a flow measurement has translated the flow into how much chemicals are needed. This gives that the flow can change without affecting the process, since theflow gives what is added in the process. This is better than having a biological plant that needs todefrost which leads to the problem that the bacteria and micro organism will not survive anotherwinter without food, in form of organic material. It is easy to run the plant and it does not need alot of efforts from the visitors and researchers.

It is important that SPRS gets a treatment plant for Wasas grey water and prevent thesurroundings of Wasa from getting more contaminated with human bacteria and dirt. SinceAntarctica is such a big resource for research about our planet and development it should be keptuntouched for the coming generations. Soon the Antarctic Treaties articles can be more adjustedto today's techniques, development and possibilities.During the last couples of years Antarctica is more accessible than before and the yearly visitorsare increasing. Both the number of researchers and tourist are increasing. The tourists are animportant key to getting more done when it comes to maintenance and keep the content clean.The tourist that visits stations may not have the same picture on how it looks as the returningresearchers and stations staff. Maybe the new comers did not think that abandoned trash wouldlie on the ground and that before the trash was sunken outside in the ocean. All this gives newinput to the active countries on what needs to be done at their station. In the end all the touristvisits will give more publicity to what happens and can occur in Antarctica.Efforts that help the Antarctic Treaty to maintain this unspoiled continent have to be done. Ifproblems are discovered the action has to come immediately after options has been looked intoand measured. New techniques that work in this environment needs to be developed and used byall possible clients. To preserve Antarctica is not a one mans mission, to get good resultseveryone has to contribute with their special knowledge.

CONCLUSION

Of all station in Antarctica 48 % of them have some kind of treatment. The permanent stationshave a higher number of treatment, 63 % and only 31 % of the summer stations have some kindof treatment. This means that a lot of countries should get treatment if they want to live up to theAntarctic Treaties articles. Sweden is soon going to join and increase today's 48 % with treatment. One treatment method for grey water is found and it is the company Emendo AB that have thefinal product. The product will use chemical precipitation and sedimentation to clean the waterbefore it will be released to the ice outside Wasa. This will minimise the environmental impactfrom SPRS in Antarctica further.

REFERENCES

1. Antarctic Treaty, can be found on SPRS homepage, www.polar.se
2. Berkman, Paul Arthur. 2002, Science into policy, Academic Press, ISBN 0-12-091560-X.
3. Bratt, Anna. 2005, Miljögifter hot mot isbjörne, DagensNyheter, Sunday the 17 of April, pp: 9.
4. Carlsson, Sten-Åke, Information by mail, works at Ekotreat, March 2005.
5. COMNAP Brazil, http://www. comnap. aq/comnap/ comnap.nsf/P/CountryByISO/BR, April 2005
6. COMNAP Italy, http://www.comnap. aq/comnap/ comnap.nsf/P/CountryByISO/IT, April 2005.
7. COMNAP, stations, www.comnap. aq/comnap/ comnap. nsf/P/PDF/1/$FILE/stations.pdf January 2005.
8. Hagum, Dan. 1994, Byggtekniska studier påforsknings stationen Wasa I Antarktis: iaktt agelserfrånmätningar 1989, Luleå TekniskaHögskola, ISSN 0347-0881.
9. IAATO, International Association of Antarctica Tour Operators, season statistics homepage, http://image.zenn.net/REPLACE/CLIENT/1000037/1 000116/application/pdf/touristsbynationality_total. pdf, April 2005
10. Jacobsson, Marie. 1992, Antarktis UD informerar, Antarktis - omsydpolenshistoria, juridikochpolitik, UD, ISSN 0347-5298
11. Johansson, Kristina. 2002. Hårvårdsprodukter- Vad de innehållerochhurpåverkasmiljön?
12. Rapport 21 maj 2002, Stockholm Vatten, can be found on this internet page, http://www. stockhol mvatten. se/ pdf_arkiv/avlopp/harvard.pdf
13. Liljequist, Gösta, H., 1993, High Latitudes –A History of Swedish Polar Travels and Research,SPRS, ISBN 91-7886-102-0 Lucas, Mike. 1996, Antarktis, WWF, ISBN 91-7115-045-5.
14. May, John. 1988, Greenpeace bokomAntarktis- En nybildav den sjundekontinentenStreiffert,Stockholm, ISBN 91-7886-034-2.
15. NASA, Press release, Exotic Microbes Discovered near Lake Vostok, NASA Marshall Space
16. Flight Center, 10 December 1999. http://science. nasa. gov/newhome/headlines/ast10dec99_2.htm

17. Naturvårsverket 1990. Småavloppsanläggningar-Hushållsspillvattenfrånhögst 5 hushåll.
18. Allmännaråd 87:6 Reviderad 1990 ISBN 91-620-0022-5
19. Nilsson, Lennart, Persson, Per-Olof. 2004, Miljös kyddsteknik–Strategier & teknik för etthåll bartmil jöskydd, Universitetsservice US AB Stockhom, Course book KTH
20. Olsson, Björn *et al*., T. Broman, S. Bergström, On S.L.W. Palmgren, H. McCafferty, D.J. Sellin, M. 2000, Isolation and characterization of Campylobacter jejuni subsp. jejuni from Macaroni
21. Penguins (Eudypteschrysolophus) in the sub-Antarctic region. Appl. Environ. Microb., 66: 449-452.
22. Olsson, Björn *et al*., H. Palmgren, D. McCafferty, A. Aspán, T. Broman, M. Sellin, R. Wollin, S. Bergström, 2000. Salmonella in sub-Antarctica: low heterogeneity in salmonella serotypes in South Georgian seals and birds. Epidemiol Infect, 125: 257-262.
23. Petersens, Ebbaaf. 2003, Småskaliga avlopp srening sanläggningar-marknad söversiktover prefabricer adepro dukterförbehandling “i slutetavröret”, VA-Forsk rapport Nr 7 februari 2003,
24. Ridderstolpe, Peter. 2004, Introduction to Greywater Management, EcoSanRes Report 2004-4,can be found on this internet page,
25. Sundberg, H. Patrik. Information by mail and phone. Ordered the product from Emendo. Heworks for the Swedish Armed Forces. 2005-05-31 Swartling, Anne. 2003, Monitoring of soil contamination at Wasa and Aboa stations, DronningMaud Land, East Antarctica
26. SWEDARP, Inspection at Wasa under the Antarctic Treaty and the Madrid Protocol, January2004, SPRS .