Invasive Alien Species
National Scientific Secretariat

Biosecurity in the management of freshwater ecosystems

Handbook of Best practices

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1. Introduction and scope

What are IAS?

Invasive Alien Species (IAS) are plant, animals or micro-organisms introduced outside their natural range by human action, whose presence can cause serious negative environmental, economic and social consequences.

Why should we be concerned?

IAS can severely impact the aquatic ecosystems' biological composition and functioning. They can devastate populations of native species and change whole ecosystems, by competing with native species, spreading diseases and parasites, altering the local ecology, and clogging waterways. The adverse effects can also impact recreational activities, by reducing fish populations, affecting water quality or restricting access and navigation through waterways.

In Belgium, aquatic plant species such as the floating pennywort or water primrose can grow very rapidly to form dense mats, reducing light and oxygen availability and leading to the biological death of the water system invaded. Exotic crayfish are also causing very negative impacts on waterways by carrying the crayfish plague, a disease harmful to our native crayfish, and by reducing populations of fish and amphibians.

Figure 1. Left: Curly waterweed - credit: Jo Packet ; Right: parrot's feather – credit: Olivier Dochi

How do they spread?

Aquatic environments are particularly vulnerable to the introduction and further spread of IAS. In addition to natural spread through water currents, recreational users and field workers can further accelerate the spread of IAS by accidentally transporting, for example, small pieces of aquatic plants, seeds or animal eggs and larvae on their used equipment, shoes and clothing. When this contaminated equipment is then used in the next location, the introduced IAS are again in a favourable environment to establish and build up a new population.

Figure 2. Unintentional transport of individual plant fragments and animals. Credit: GB NNSS and Tim Adriaens

Prevention is better than cure!

Preventing new introductions of IAS is much more cost-efficient than trying to control already established populations. Especially in the aquatic environment, eradicating a species after it has been established is in many cases impossible, and the maintenance costs and the damage to industry and infrastructure increase exponentially every year. Whereas in 2013 the costs in Europe were still 19.64 trillion euros, they were estimated at 116.24 trillion euros in 2020 - and this is probably a gross underestimate. And that is not to mention the often irreversible damage that invasive populations cause to wetlands. It is clear that preventive measures are indispensable to protect our nature and the industries that depend on it and recreation in the aquatic environment. An analysis of all introduction and dispersal routes in Belgium identified the transport of IAS via recreational users' equipment or managers' tools and machinery as one of the priority pathways along which preventive measures should be taken.

What is biosecurity?

The objective of implementing biosecurity measures in the daily management of aquatic systems is to **prevent** entry and/or spread of invasive freshwater species. Preventative actions - in the long run - the most (cost-)effective measures to tackle invasive alien species. The main message that should be retained is to **keep your equipment free of (invasive) plants and animals** when moving from one location to another. This applies not only when you are specifically managing invasive alien species, but also when you are

performing other tasks in the vicinity of a waterbody (*e.g.* surveying, garbage removal, working on banks, ...).

2. Check-Clean-Dry

The most important biosecurity principle which should be applied on all equipment and clothing follows three steps:

- **CHECK**: Check for mud, small aquatic animals, plant fragments and seeds. Remove and leave at the site away from the waterway or dispose in general waste when the check is performed off site. Pay particular attention to damp areas of the equipment and clothing.
- **CLEAN**: Clean thoroughly with water (freshwater hose, or water transported for that purpose). Use hot water if possible, and the best is hot pressurised water. Alternatively, hot water dipping in 60°C for 1 minute can be used for nets.
- **DRY:** Plant and animals can survive for two weeks in damp conditions but drying will kill aquatic IAS. Drain excess water and then let your equipment dry for as long as possible and at least 48 hours. When drying is not possible disinfect the equipment after cleaning (ethanol 70%) to make sure bacteria, viruses and fungae are dead before the equipment is used in another aquatic location.

Figure 3. Left: Storage of duplicate sets of material; Right: extra attention when checking shoes, waders and nets. Pictures: GB NNSS

3. Detailed biosecurity guidelines

Planning

The biosecurity measures start when planning the fieldwork, with the following recommendations:

- **Assess presence of IAS and diseases at the sites that will be visited:**
  - Assess the **status of IAS** at the site and reflect on the timing of the works (*e.g.* are there IAS plants in seed and if so, can works avoid the area the IAS is established in or be postponed or done earlier in the year);
  - When visiting multiple sites, **plan the contaminated sites as the last ones** of the day, or even on a separate day;
  - Bring **separate sets of equipment** for selected contaminated sites;
  - When working on rivers and streams, plan you work in the downstream directions to avoid bringing contamination upstream.
- **Arrive clean, leave clean:**
  - Allocate time for cleaning your equipment;
  - Assess the **conditions** that will determine the **type of cleaning** feasible that day and bring the relevant kit;
  - **Checklist** of equipment for cleaning/disinfecting;
  - Bring **separate sets of equipment** for sites of high conservation value.
- Where possible, clean on site and leave any material removed from equipment at site, away from the water and from high-traffic areas. If not possible, plan how you can **dispose safely of any soil, vegetation or material** you are taking away from a site;
- When ordering new equipment, **favor equipment than can be cleaned easi**ly.

Before

Before leaving on fieldwork or before entering the site, the following precautions should be taken:

- Check if the equipment was cleaned, and verify it is dry (if not, take a spare kit or clean thoroughly and properly disinfect before taking it) ;
- Clean footwear and vehicle tyres, before entering the site;
- Assess how you can enter the site with the least amount of risk - minimise access with vehicles to the site or try to stay on paved roads.

After

The *check-clean-dry* procedure (see above) should be applied at the end of each day, or better after each site visited. If there is not time to dry the equipment between sites, it should be disinfected. Ideally, the procedure is done on site, but it can also be done off site.

For cleaning, use hot water if possible. If applying hot water through a pressure hose, do not make sweeping motions, but rather **apply it from a short distance** (10cm) for an extended amount of time before moving to the next zone to ensure the temperature treatment is efficient.

Species-specifics

Below, you can find guidelines for the prevention of IAS spread, related to specific groups of IAS that are associated with aquatic habitats.

1. **Plants on banks**

Prevention of spread: Pay attention when transporting and disposing of habitat material (soil) as it can contain plant fragments or seeds, clean machinery that was in contact with the soil after working in the close vicinity of an infected site. Avoid walking through plant stands. Check and clean your boots and clothing to prevent transport of seeds and plant fragments. Do not leave any plant material in or close to the waterbody – and make sure plant fragments resulting from mowing or other management cannot be transported by the water (by putting up nets for example). Work upstream to downstream.

2. **Aquatic plants**

Prevention of spread: Avoid transportation of plant fragments via machinery, gear, boots and clothes. When removing habitat material, dispose of it on a dry spot away from the water (but still on location); avoid mowing of banks too close to the water surface; collect all fragments that were dislodged during management; work upstream to downstream.

3. **Aquatic animals (fish, amphibians, crayfish)**

Prevention of spread: Disinfect your gear to prevent spreading eggs, parasites, and very importantly, invisible diseases that are very harmful to our native aquatic animals.

4. Disinfection

Disinfection of vehicles, boots and clothing ensures that micro-organisms which pose a danger to the native fauna are killed before the gear is transported to another location which might not be infected. This is important because these micro-organisms, which cannot be seen with the naked eye, are not removed by cleaning routines and can survive for multiple days on moist surfaces. Some examples of such micro-organisms are the crayfish plague (*Aphanomyces astaci*), the Ranavirus and the fungus *Batrachochytrium dendrobatidis*.

Disinfection can be brought about by chemical disinfectants and heat treatments, though the latter requires a lot of extra time, is not possible for a lot of equipment and not applicable in the field. Therefore it will not be discussed below.

In Belgium, we recommend the use of **70% Ethanol** as disinfectant as it is commonly available and can be used without legal restrictions.

- **Use :**
  - 70% Ethanol
  - Spray the solution on the equipment and leave to act for at least 1 minute

For the specific case of work around amphibians habitats, the chemical disinfectant **Virkon S®** can be used – as it is the most efficient against the range of infectious agents (bacteria, viruses and fungi) – **but a specific permit for the use of this biocide is required**.

- **Use :**
  - 1% Virkon S® solution (10 grams per liter water)
  - Disinfect at least 6 meters away from the waterbody.
  - The solution should not come into contact with the soil (disinfect in containers or place plastic tarps below the equipment to be contaminated).
  - Depending on the equipment to disinfect, the solution can be sprayed on with a spraying bottle, the equipment can be dipped into the solution (*e.g.* for nets) or the solution can be applied with a cloth on hard surfaces.
  - Leave the solution to act for minimum 10 minutes on the equipment.
  - The residue (in the container or tarp) should be discarded through the recycling center (not the sewer).
- **Storage :**
  - The product has a pink dye indicator when mixed. The solution becomes ineffective when the pink colour disappears. Direct sunlight will also cause the pink colour indicator to fade more rapidly.
  - There is a 20% loss of activity of 1% solutions of Virkon® after 14 days in very hard water (350 ppm). To maintain high efficacy, it is recommended to discard Virkon S® solution after 7 days.
  - It is recommended that Virkon S® powder or tablets are stored dry at 15 to 25°C. Virkon S® solution can be stored at room temperature, however, higher temperatures will reduce lifespan of the solution.
- **Safety precautions :**
  - Powder is irritating to eyes, skin, and mucous membranes. May be harmful if swallowed or inhaled. Do not get powder in eyes. Avoid contact of powder with skin.
  - There are no occupational exposure limits for 1% Virkon S® solution. It is considered a non-irritant to skin and eyes, and is of low toxicity.
  - Disposal of Virkon S® through the recycling center.

5. Material

Material Checklist

- **General cleaning equipment**
  - Hard brush and sponges
  - Hoof pick
  - Small soft brush
  - Large flexible bucket
  - Large container of clean freshwater (5L)
- **Transport and protection**
  - Plastic foot baths
  - Plastic tubs to contain equipment for transport
  - Rubbish bags & ties – heavy duty
- **Disinfection kit**
  - Disinfecting product (e.g. 70% Ethanol)
  - Cloths or sponges, scrubbing brush
  - Spray bottles

Figure 4. Example of a Biosecurity kit (Yorkshire Water, UK). Left below: Hoof pick to clean boot tread. Right below: Boot buddy®, a handy tool for cleaning shoes and boots. Pictures: NSSIAS

6. References and additional resources

Biosecurity guidelines

- **Bradbeer, Stephanie J., et al.** "The effectiveness of hot water pressurized spray in field conditions to slow the spread of invasive alien species." Management of Biological Invasions12.1 (2021): 125-147.
- **GB Non-native species secretariat, 2022:**
  - Check, Clean, Dry - Help stop the spread of invasive plants and animals in our waters!
  - Biosecurity for field workers
- **Inland Fisheries Ireland, 2010.** IFI Biosecurity protocol for field survey work
- **Miaud C., 2022** - Hygiene protocol for amphibian disease control in the field. The École Pratique des Hautes Étude (ed), 9 pages.
- **Natural resource management South,** https://nrmsouth.org.au/biosecurity/
- **Natuurpunt, 2021.** Preventie van de verspreiding van infectieziekten chytridiomycose en ranavirose bij amfibieën – 2021; veiligheidsvoorschriften veldwerkzaamheden (ANB, WHG, INBO, Natuurpunt)
- **NSW Department of Industry,** Procedure: Aquatic fieldwork hygiene, RM8 Ref: INT17/26050
- **Shannon, Caitriona, et al.** "The practical application of hot water to reduce the introduction and spread of aquatic invasive alien species." Management of Biological Invasions 9.4 (2018): 417-423.
- **Yorkshire invasive species forum,** https://yisf.org.uk/resources/
- **Yorkshire Water** – Personal communication with Dr Steph Bradbeer

Species

In French

- Plantes: http://www.iasregulation.be/fr/358/
- Animaux : http://www.iasregulation.be/fr/350/
- http://biodiversite.wallonie.be/fr/especes-preoccupantes-pour-l-union.html?IDC=6022

In Dutch

- Planten: http://www.iasregulation.be/nl/358/
- Dieren: http://www.iasregulation.be/nl/350/
- https://www.ecopedia.be/pagina/exoten

Supplementary Material
Species information

Below, you can find information related to specific **invasive alien species of the Union list** that are 1) present in Belgium, 2) associated with aquatic habitats and 3) for which increased biosecurity can curb their spread. You can find information on their distribution and their reproduction (i.e. how they spread) and a link to the best practices. Identification aids for invasive alien plants and animals of the Union list can be found on www.iasregulation.be (see links above in the section "additional resources" - "species").

Plants

1. On banks

Heracleum mantegazzianum

- Distribution: Widespread in the whole of Belgium
- Reproduction: The species reproduces only by seeds. Inflorescences start to develop in May, with peak flowering in June-July. The species produces tens of thousands of seeds that disperse mainly via water or via wind along transport corridors. Seeds can be very prevalent in the soil and can remain viable for at least 2 years.
- Do not touch the plant yourself as it can cause very painful blisters. If a plant is spotted on an area where you are working – notify for eradication
- Guidelines for management:
  - https://www.onkruidvergaat.nl/wp-content/uploads/Leidraad-beheer-Reuzenberenklauw.pdf (NL)
  - https://purews.inbo.be/ws/portalfiles/portal/17374269/Report_Manageability_final_cvr.pdf (ENG)

Impatiens glandulifera

- Distribution: Widespread in the whole of Belgium and very common in riparian areas.
- Reproduction: The species reproduces only via seeds. Flowering runs from June to October. The ensuing seed capsules explode when they are mature, catapulting the seeds up to 7 meters. One plant can form up to 800 seeds, of which the majority germinate after one year, but some remain viable for a second year.
- Guidelines for management:
  - https://purews.inbo.be/ws/portalfiles/portal/17374269/Report_Manageability_final_cvr.pdf (ENG)

Lysichiton americanus

- Distribution: A few large populations (Ourthe, Limburg) and smaller populations near gardens. Habitat: grows in the transition zone of terrestrial, semi-aquatic and aquatic

habitats like swamps, fens, wet meadows, marshy and alluvial woodlands, along streams, riverbanks, lakesides and ponds.

- Reproduction: The species reproduces mainly via seeds which remain viable for about 9 years, but can also regenerate from rhizomes. The seeds usually fall very close to the mother plants, but when growing in running waters, berries can be transported over water. Fragmentation of rhizomes, dispersal via machinery and subsequent establishment is possible, yet more rare.
- Guidelines management:
  - https://purews.inbo.be/ws/portalfiles/portal/17374269/Report_Manageability_final_cvr.pdf (ENG)

2. Aquatic floating plants

Ludwigia grandiflora and *L. peploides*

- Distribution: *L. grandiflora:* relatively widespread North of Samber and Maas, South of Samber and Maas only a few small and isolated populations; *L. peploides*: some large populations North of Samber and Maas
- Reproduction: Both species root in the banks and forms floating mats on the water surface and colonises the surrounding wet terrestrial habitat. They are mainly found in standing or slow flowing waters. The species mainly reproduces clonally. Stem fragments can give rise to new plants. The species flowers in June-August and also forms seedbanks.
- Guidelines management
  - https://ecopedia.s3.eu-central-1.amazonaws.com/pdfs/Eindrapport%20GWN%20EAIW%202013-03-26.pdf (NL)
  - https://purews.inbo.be/ws/portalfiles/portal/17374269/Report_Manageability_final_cvr.pdf (ENG)

Hydrocotyle ranunculoides

- Distribution: Widespread North of Sambre and Meuse, rare South of Sambre and Meuse
- Reproduction: The species produces seeds that can be transported over water. However, in Europe, reproduction is mainly through vegetative fragmentation. Only a small fragment is enough to give rise to big infestations.

3. Aquatic submerged plants

The following plants grow in the water column.

Cabomba caroliniana

- Distribution: Only present in some isolated sites in Flanders
- Reproduction: Though this species can self-pollinate and produce seeds, vegetative reproduction is the most important means of spread. This water weed produces rhizomes which can easily break into fragments that can easily regenerate new plants.

This happens more readily after flowering, but can occur troughout any time of the year.

Elodea nuttallii

- Distribution: Widespread in the whole of Belgium. It is found in ponds, canals, river branches and slow flowing stretches of rivers.
- Reproduction: The species can produce seeds, but in Belgium and the Netherlands, only female plants have been spotted. The plant easily fragments into small shoot pieces that can regenerate new plants.
- In winter: the species overwinters with stems that lay on the bottom the waterbody

Lagarosiphon major

- Distribution: Established populations throughout Belgium
- Reproduction: Since there are only female plants in Belgium, this submerged rooted weed only reproduces vegetatively via fragmentation.

Myriophyllum aquaticum

- Distribution: Widespread in the whole of Belgium, more common in Flanders.
- Reproduction: Mainly vegetatively trough fragments that can root
- In winter: the species overwinters with rhizomes

Myriophyllum heterophyllum

- Distribution: Isolated populations in Flanders (Antwerp) and Wallonia
- Reproduction: The species rarely flowers and it is thought that male plants are absent in its invaded range. Reproduction is thought to happen mostly vegetatively via fragmentation. The rhizomes are very robust and can root even after many months when kept moist.

Animals

To be developed

4. Freshwater fish

Prevention of spread:

Lepomis gibbosus

- Distribution: Very common north of Samber and Maas. Rather rare south of Samber and Maas. High densities in canals and artificial waterbodies.
- Reproduction: The species reproduces in the summer by laying eggs in nesting holes, preferably in rather shallow and sunny parts of the waterbody.

Pseudorasbora parva

- Distribution: Very abundant and widespread.
- Reproduction: While the species also occurs in rivers, it mainly reproduces in spring via eggs in non or very slow flowing waters.
- Other issues: In the Netherlands, this fish is know to carry a monocellular disease (*Sphaerothecum destruens*) that can kill native fish or hamper their reproduction.

5. Amphibians:

Lithobates catesbeianus:

- Distribution: Large populations in the valley of "de grote Nete" and expanding. A few smaller populations north of the Valley of the Samber and Maas.
- Reproduction: De reproduction period starts mid-April and ends in September. Eggs are layed at the surface of the water in clumps of 1000 to 30 000 eggs. Clumps can be 30 to 150 cm large.
- Other issues: The species is a carrier of many amphibian diseases, including the cause of chytridiomycosis that wreaks havoc among our native amphibians

(invisible) amphibian diseases that can be transported by moist gear:

- *Batrachochytrium salamandrivorans:*
- *Batrachochytrium dendrobatidis*
- *ranavirus*

6. Invertebrates

Crayfish: *Orconectes limosus, Pacifastacus leniusculus, Faxionus clarkii, Faxionus virginalis*

Distribution: Overall, invasive alien crayfish are widespread in Belgium – though the exact extent depends on the species of interest.
Reproduction: Fertilised eggs carried under the tail. Timing of reproduction is very dependent on temperature conditions and ranges from spring to autumn in Europe.
Female *Faxionus virginalis* can produce viable eggs without the need for a male.
Other issues: Invasive alien crayfish can carry the crayfish plague (*Aphanomyces astaci*). They don't get very sick from it, but it's deadly to our native crayfish *Astacus astacus*.

Crab: *Eriocheir sinensis*

Distribution: very abundant in the Schelde and its side rivers. Rarer in the catchment area of the Maas.
Reproduction: Although the crab is considered as a freshwater species, it is dependant on seawater for its reproduction. From August onwards, adults move towards the estuaries and tidal areas to reproduce.