Hydro Nation Scholars Programme

Removal of pesticides from freshwater environments

Policy Brief

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Overview

- Conventional water treatment (coagulation, flocculation, sedimentation/flotation and filtration) might be inefficient to remove pesticides. Photocatalysis is a technology with great potential for the removal of pesticides from water.
- The recovery of powdered catalyst from water and the high costs associated with the implementation of UV illumination represent a challenge to the application of photocatalysis. Glass beads coated with graphitic carbon nitride (g-C_3N_4) and LEDs were successfully applied to overcome these issues.
- The degradation of a mixture of nine different pesticides was achieved by photocatalysis based on g-C_3N_4 coated beads and UV-A LED.
- A scalable photocatalytic treatment was developed to promote pesticide removal at source.

Introduction

Pesticides can be carried over through air during their application in agriculture, finding their way to aquatic environments such as surface and groundwaters and eventually end up in drinking water [1,2]. Effluents containing residual pesticides or other toxic degradation products can also contaminate freshwater environments (e.g., pesticide spray tank residuals, pesticide storage tanks, drainage channels next to crops and ponds) [2]. Furthermore, rainfall runoff represents a primary pathway for the transport of pesticides [3]. Pesticide contamination in freshwater environments, such as rivers, lakes, estuaries, dams, streams and groundwater systems, may result in negative impacts to plants, animals and humans [4]. Conventional water treatment (coagulation, flocculation, sedimentation/flotation and filtration) can be inefficient in removing dissolved compounds such as pesticides as this technology is designed to treat suspended and colloidal particles [5], therefore, it is important to remove pesticides from aquatic environments at source. Photocatalysis is one technology with great potential for the removal of pesticides from water.

Research Undertaken

Photocatalysis is a technology that can be used for the removal of pesticides from water. The recovery of powdered catalyst from water and the high costs associated with the implementation of UV illumination represent a challenge to the application of photocatalysis at source. To overcome these challenges, glass beads were used as immobilisation matrix for powdered catalyst and low-cost light emitting diodes (LEDs - £0.6/LED) were used to activate the catalyst. A prioritization strategy of pesticides was created based on the toxicity, worldwide occurrence in the environment, persistence, ecological risk, usage in Scottish farms, physical-chemical characteristics and impacts on humans and other organisms. Acetamiprid, clothianidin, imidacloprid, thiacloprid, thiamethoxam, dimethoate, diuron, atrazine and 2,4-dichlorophenoxyacetic acid

(2,4-D) were the pesticides investigated. The efficiency of graphitic carbon nitride ($g\text{-}C_3N_4$) coated beads and UV-A LEDs on the photocatalytic removal of a pesticide mixture was evaluated in bench-scale. A pesticide mixture containing all selected pesticides in artificial freshwater (1 mg L^{-1} each pesticide) was used. High performance liquid chromatography was used to quantify pesticides. The results obtained from the bench-scale experiments were used as proof-of-principle for the development of the photocatalytic treatment unit that could be used for pesticide degradation at source.

Key Findings

All pesticides were completely degraded over 48 hours of photocatalytic treatment by $g\text{-}C_3N_4$ coated beads and UV-A LED irradiation, however, complete degradation of individual pesticides could be observed from 4 hours of photocatalysis (e.g., diuron). The proposed photocatalytic system was able to successfully remove several different pesticides at the same time even when higher concentrations than the ones commonly found in the environment were present in comparison with concentration usually found in the environment. The degradation efficiency of the photocatalytic system used in the current study demonstrates the possibility of application of $g\text{-}C_3N_4$ coated beads and UV-A LEDs for the removal of pesticides at source (Figure 1). A prototype based on $g\text{-}C_3N_4$ coated beads and low-cost LED irradiation was developed (Figure 2).

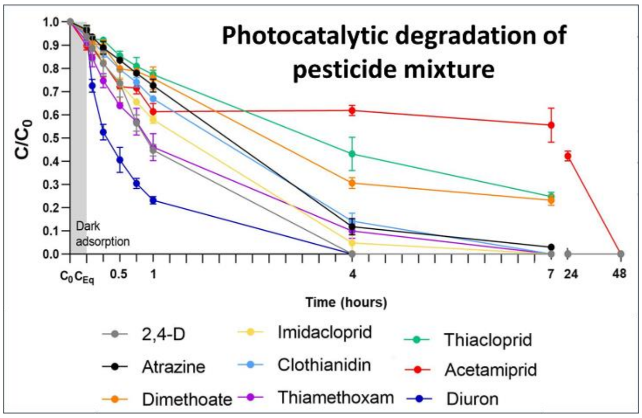

Figure 1 – Photocatalytic degradation of pesticide mixture

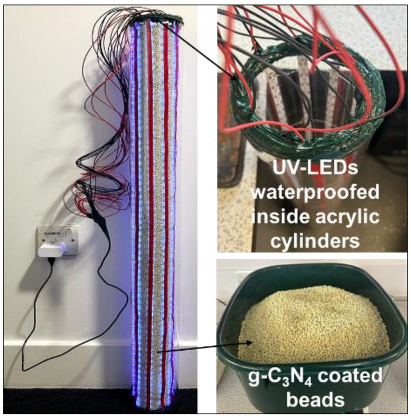

Figure 2 – Prototype of photocatalytic treatment unit

Conclusions

Large-scale experiments using the photocatalytic treatment unit are still required, however, the proposed photocatalytic reactor is a low-cost (£204 per treatment unit), flexible (several units can be used at the same time), portable (1 m x 0.1 m) and easy to use prototype that can be used in different scenarios in any farm. Potential deployment locations in farms include storage tanks containing residual pesticides, ponds, drainage channels and other aquatic environments near farms.

Policy Implications or Recommendations

The proposed prototype provides a photocatalytic treatment unit that empowers communities to meet the regulatory limits of pesticides in aquatic environments at source. The photocatalytic treatment could also be applied in different activities. For instance, pesticides are also applied in aquaculture as a medicine for the control of salmon lice. Different pesticides can be used as medicine, such as imidacloprid, azamethiphos, deltamethrin and cypermethrin. A possible application of the proposed reactor is to treat the water used during medicinal bath treatment before its discharge to the sea. Furthermore, this technology has the potential to be applied in different water treatment scenarios, such as complimentary steps to ease the burden on potable water treatment, as localized treatment in lakes or reservoirs, as a polishing step before the discharge of treated water into the environment and as main water treatment in agriculture and aquaculture industries.

References

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