Can industrial utilization of invasive aromatic weeds be a sustainable approach for their management?

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Plants which grow in unwanted areas or in permanently human-disturbed habitats, but do not depend on human intervention for their reproduction and survival are called weeds. Some of these weeds, usually invasive in nature, are seen to have adverse effects on agricultural and natural ecosystems. They are responsible for deterioration of biodiversity, species extinction, and changes in hydrology and ecosystem function leading to ecological imbalance. Further, control measures and policies often consider weeds as problematic plants; therefore, management of these is sometimes being done indiscriminately without focusing on their economic significance. Despite their obnoxious nature, certain weeds are reported to have diverse medicinal properties and find uses in various traditional systems of medicine. In addition

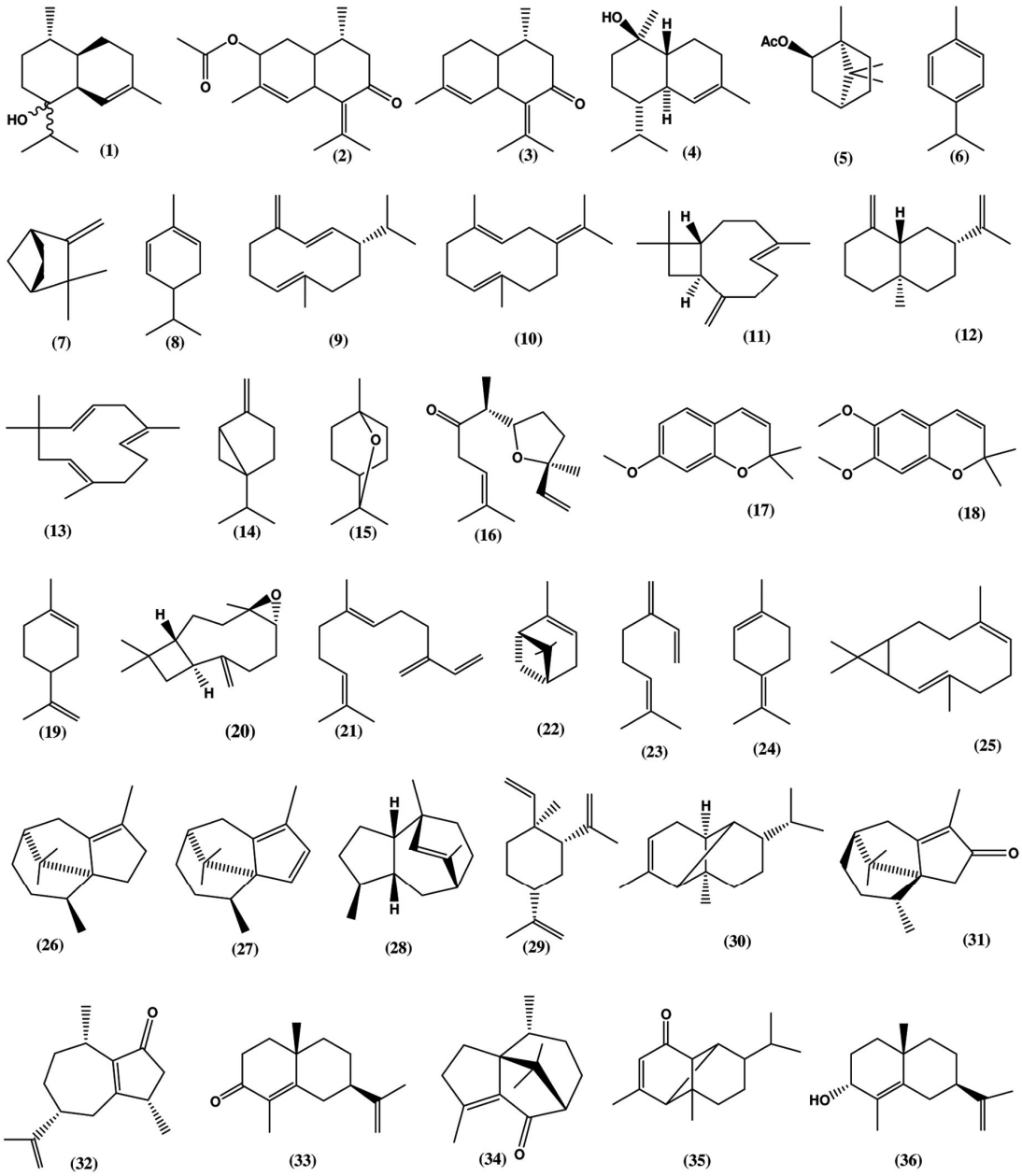

Figure 1. Structures of the major constituents of essential oils of various invasive aromatic weeds.

to medicinal values, certain invasive weeds, namely *Eupatorium adenophorum* Spreng, *Lantana camara* L., *Ageratum conyzoides* L., *Cannabis sativa* L., *Sphagneticola trilobata* (L.) Pruski (syn. *Wedelia trilobata* L.), *Cyperus rotundus* L., *Parthenium hysterophorus* L., etc. are aromatic in nature due to presence of essential oils. These oils are a complex mixture of terpenes (mono-, sesqui- and sometime even diterpenes) and their oxygenated derivatives. Phenyl alkanoids (ethanoids, propanoids and butanoids) and some other classes of compounds also occur in some essential oils. The essential oils are generally extracted by hydro- or steam distillation of plant biomass and extensively utilized in flavour, fragrance, cosmetic and pharmaceutical industries.

Figure 1 shows the structures of the marker/major aromachemicals of various invasive aromatic weeds. In the last few decades, certain invasive aromatic weeds have been studied around the globe for their valuable essential oils and aromachemicals. The aerial parts of *E. adenophorum* collected from the Himalayan region of Uttarakhand yield 0.56% essential oil on hydrodistillation. Amorphenes, namely amorph-4-en-7-ol (**1**), 3-acetoxyamorpha-4,7(11)-dien-8-one (**2**) and amorph-4,7(11)-dien-8-one (**3**) along with α-cadinol (**4**), bornyl acetate (**5**), *p*-cymene (**6**), camphene (**7**) and α-phellandrene (**8**) are the major constituents of the essential oil[1]. *L. camara* possesses 0.40% essential oil, which is dominated by germacrene D (**9**), germacrene B (**10**), (*E*)-caryophyllene (**11**), β-selinene (**12**) and α-humulene (**13**) as major constituents. Other important constituents of this oil are sabinene (**14**) and 1,8-cineole (**15**)[1]. Moreover, *L. camara* leaf oil rich in *cis*-davanone (**16**) is also described from Northeast India[2]. The fresh aerial parts of *A. conyzoides* yield 0.30% essential oil. This oil is characterized by the presence of higher amount of precocene I (**17**), precocene II (**18**), (*E*)-caryophyllene (**11**) and α-humulene (**13**)[1]. The fresh herb of *C. sativa* yields 0.10–0.13% essential oil, which is considered to be free from psychoactive substances. Major constituents of *C. sativa* essential oil are (*E*)-caryophyllene (**11**), limonene (**19**), caryophyllene oxide (**20**), (*E*)-β-farnesene (**21**), α-humulene (**13**), α-pinene (**22**), myrcene (**23**), terpinolene (**24**) and β-selinene (**12**)[3]. The fresh herb of *S. trilobata* yields 0.18–0.25% essential oil, which is primarily composed of α-pinene (**22**)[4]. However, *S. trilobata* oils rich in a germacrene D (**9**), α-phellandrene (**8**), α-pinene (**22**), (*E*)-caryophyllene (**11**), bicyclogermacrene (**25**), limonene (**19**) and α-humulene (**13**) are also reported[4]. Moreover, the essential oil yield (0.4–0.6%) and chemical composition of the tubers of *C. rotundus* vary from place to place; however, frequently reported characteristic constituents of the oil are cyperene (**26**), cypera-2,4-diene (**27**), rotundene (**28**), β-elemene (**29**), α-copaene (**30**), β-selinene (**12**), caryophyllene oxide (**20**), cyperotundone (**31**), rotundone (**32**), α-cyperone (**33**), patchoulenone (**34**), mustakone (**35**) and cyperol (**36**)[5].

Invasive aromatic weeds produce a number of secondary metabolites of aromatic and medicinal significance. Some of them are highlighted above. Therefore, these weeds can be explored and processed for utilization in flavour, fragrance, cosmetic and pharmaceutical industries. Moreover, increasing importance of natural extracts as pharmaceutical and natural cosmetic aids and their use as food ingredients in recent times have opened up new vistas for this sector besides their widespread use as flavour and fragrance ingredients. Thus, further phytochemical and pharmacological studies on invasive aromatic weeds may contribute to the development of important pharmaceutical, perfumery, flavour and cosmetic products for future industrial use. At the same time, sustainable industrial utilization may be a solution to the problem, being created by indigenous or exotic invasive aromatic weeds to the environment, agricultural economics and natural ecosystems. Therefore, sustainable harvesting of invasive aromatic weeds for aroma/bioactive principles, i.e. management by utilization may substantially reduce the cost and time involved in the chemical, mechanical and biological weed control measures for biodiversity conservation and cultivating various agricultural crops. In this way, we can not only conserve our biodiversity from the invasive weeds, but can also generate raw materials at low inputs for extraction of valuable phytomolecules for industrial utilization. Moreover, considering the issues of biodiversity, all forms of life such as flora, fauna and microbes, whether beneficial or harmful, need to be conserved. Therefore, a sustainable approach will be needed for collection and processing of these plants.

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