Review Article

A Perspective on therapeutic potential of weeds

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Abstract

Nature gives us a diverse plethora of floral wealth. Weeds have been recognized as invasive plant by most of scholars in today’s world with extraordinary travel history. They are considered to be noxious for adjoining plant species and also as economic hazard. Weeds inhabited in almost entire biomes and have capability to survive in harsh conditions of environment thereby become source of inspiration for finding novel phytoconstituents. Weeds play a significant role in absorbing harmful micro pollutants that are affecting ecosystem adversely. There are so many examples like canna lily, bladder wort, coltsfoot, giant buttercup etc. playing crucial part in absorbing harmful micro pollutants that are affecting ecosystem adversely. Different isolation and characterization approaches like high pressure liquid chromatography, gas chromatography, ion exchange chromatography, nuclear magnetic resonance, mass spectroscopy etc. have also been fetched for obtaining novel constituents from weeds. The main aim of this review is to analyze the therapeutic potential of weeds established in New Zealand and effort to unfold the wide scope of its applications in biological sciences. Upon exploration of various authorized databases available it has been found that weeds not only are the reservoir of complex phytoconstituents exhibiting diverse array of pharmacological activities but also provide potential role in environment phytoremediation. Phytoconstituents reported in weeds have immense potential as a drug targets for different pathological conditions. This review focuses on the literature of therapeutic potential of weeds established in New Zealand and tried to unveil the hidden side of these unwanted plants called weeds.

Introduction

‘Horse Hoeing Husbandry’ named famous writing by Jethro Tull (1731) mentioned first time the word ‘weed’ [1]. Weeds may be considered as plants whose abundance must be over above a specific level can cause major environmental concern [2]. Aldrich and Kremer, 1997 defined weed as a part of dynamic ecosystem [3]. Plant originated in natural environment and, in response to imposed or natural environments, evolved, and continues to do so, as an interfering associate with crops and activities. Weeds may interfere with the utilization of land and water resources thereby adversely affect human welfare [4]. According to Ancient Indian Literature earth is blessed with diverse flora and every existing plant has their own importance. Some plants are considered unwanted but they may have beneficial properties. Scholars are trying hard to explore the hidden potential of such unwanted plants [5]. Weeds have interactions with other organisms and some of these interactions can have direct effects on the functioning of agro-ecosystem [6]. They serve as an indirect resource for predatory species [7] and it could alternative food sources for organisms that play prominent role in insect control [8]. Weeds have a unique travel history. Clinton L. Evans in his book ‘The war on weeds in the prairie west- An Environmental History’ mentioned about travelling of weeds in ships, railways, automobiles from one country to another as food contaminants, animal feed, farm implements etc. during trade [9]. Weeds are firmly distributed and established all over New Zealand. Authors Ian Popay, Paul Champion and Trevor James in their book ‘An Illustrated Guide to Common Weeds of New Zealand’ (edition 3rd) published by New Zealand Plant Protection Society in 2010 mentioned the detailed description of around 380 weed species established in New Zealand [10]. Different scientific databases/ information resources (governmental, private, universities, initiatives, organizations etc.) of New Zealand extensively explored over a year as mentioned in table 1 to obtain data pertaining to weeds prevalent within geographical boundaries of New Zealand. After obtaining desired data of different weeds, a literature search was performed using the keyword “Name of weed (e.g. Aristea ecklonii) Pharmacology”, “New Zealand plants”, “weed pharmacology”, “therapeutic weed” individually or all together in different scientific databases of Scopus, Web of Science and Pubmed to obtain therapeutic potential of weeds. Celastrus orbiculatus (Climbing spindle berry) [59], Robinia pseudoacacia (False acacia) [63], Daphne laureola
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Chemical profile of weeds established in New Zealand

Weeds established in New Zealand encompass wide array of therapeutic phytoconstituents. Weeds serve as biosynthetic factory for synthesis of phytochemicals. They are sources of rich medicinal wealth which includes primary metabolites (polysaccharides and secondary metabolites (alkaloids, flavonoids, glycosides, tannins, volatile oils etc). They are the potential sources of complex phytoconstituents. Selaginella kraussiana (African club moss) [11], Lonicer japonica (Japanese honeysuckle) [32], Eriobotrya japonica (Loquat) [35] and Anredera cordifolia (Mignonette vine) [38] contains polysaccharides. Alternanthera philoxeroides (Alligator weed) [13] and Rhamnus alaternus (Evergreen buckthorn) [26] contains anthraquinone glycosides. Lamium galeobdolon (Artillery plant) [14] and Heracleum mantegazzianum (Giant hogweed) [27] contains appreciable amount of volatile oil. Modern spectroscopic methods have been explored for structural elucidation of bioactive constituents present in weeds. LC-MS has been used for quantitative detection of xyloglucan oligosaccharide in Selaginella kraussiana [11], betulonic acid in Alnus glutinosa (Black alder) [12], jasmonic acid in Drosera capensis (Cape sundew) [20], flavonoids in Gunnera tinctoria (Chilean rhubarb) [24], pyrrolizidine alkaloid esters in Gymnocoronis spilanthoides (Senegal tea)

Table 1: Description of scientific databases/information resources of New Zealand for weed identification.

| PRIMARY INFORMATION SOURCES | SECONDARY INFORMATION SOURCES* |
|-----------------------------|---------------------------------|
| Source name | Source type | Authors | Web address | Database/information resource |
| An encyclopedia of New Zealand, 1966 | Encyclopedia | McLintock AH | http://www.agpest.co.nz | AgPest: It is an open access tool available for New Zealand farmers and agricultural professionals containing information about weeds, pest identification, their biology, impact and management |
| Common weeds in New Zealand, 1976 | Book | Parham BEV, Healy AJ | http://www.agriculture.vic.gov.au | Agriculture victoria : Platform is used to promote agriculture industry in New Zealand and encompass information related to weeds and plant protection |
| Weeds in New Zealand protected natural areas: A review for the Department of Conservation, 1990 | Book | Williams PA, Timmins SM | http://www.cropsience.bayer.co.nz | Bayer crop science: It is one of the major information providers of crop protection products |
| Problem weeds on New Zealand islands, 1997 | Book | Bourdzt GW, Fowler SV, Edwards GR, Kriticos DJ, Kean JM, Rahman A, Parsons AJ | http://www.learnz.org.nz | Learnz: It is a initiative of free virtual field trips that help students to acquire inaccessible knowledge regarding various agricultural activities |
| New Zealand Journal of Agricultural Research, 50(2), 2007 | Journal | Howell C | http://www.massey.ac.nz | Massey university: In Massey University, College of Sciences prepared a database dedicated to provide information regarding weeds in New Zealand |
| Consolidated list of environmental weeds in New Zealand, 2008 | Journal | Sullivan JJ, Williams PA, Timmins SM, Smale MC | http://www.mpi.govt.nz | Ministry for primary industries: The Ministry for Primary Industries is dedicated to improving agriculture productivity, food safety, increasing sustainability and reducing biological risk |
| New Zealand Journal of Ecology, 33 (2), 2009 | Journal | Popay I, Champion P, James T | http://www.nzpcn.org.nz | New Zealand plant conservation network: This network system is framed to conserve the floral wealth of New Zealand |
| New Zealand Journal of Ecology, 39(1), 2015 | Journal | McPine KE, Lamoureux SL, Westbrooki I | http://www.ourbigbackyard.nz | Our big backyard: This aims to restore, create and maintain healthy habitats of New Zealand |
| Agronomy, 9, 2019 | Journal | Ghanizadeh H, Harrington KC | http://www.waikoregion.govt.nz | Waikato: This local government body works for maintaining agriculture resources and sustainability to ensure strong economy |
| Climate change risk assessment for terrestrial species and ecosystems in the Auckland region. Auckland Council, 2019 | Technical report | Bishop C, Landers TJ | http://www.weedbusters.org.nz | Weedbusters: Programme facilitates to eradicate weeds in New Zealand |

*Secondary information resources/databases have been explored from March 2019 to March 2020
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NMR employed for characterization of compounds present in *Fraxinus excelsior* (Ash) [15], *Berberis glaucocarpa* (Barberry) [17], *Ligustrum sinense* (Chinese privet) [25], *Rhamnus alaternus* [26], *Cestrum parqui* (Green cestrum) [30], *Ranunculus sardous* (Hairy buttercup) [49]. Detailed summary of chemical compounds isolated from weeds established in New Zealand indicated in table 2.

**Therapeutic potential of weeds established in New Zealand**

Weeds have been explored for diverse pharmacological actions like anti cancer, anti microbial, anti-inflammatory, antioxidant, antiviral etc. as mentioned in table 3 and figure 1.

**Anticancer weeds:** Some important cytotoxic weeds

| Common name          | Botanical name               | Native of            | Compound reported                                                                 | Analytical approach adopted                        | References |
|----------------------|------------------------------|----------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------|------------|
| African club moss    | Selaginella kraussiana       | Africa               | Xyloglucan oligosaccharide                                                        | Matrix assisted laser desorption ionization         | [11]       |
|                      | Selaginellaceae              |                      |                                                                                   | time of flight (MS), high performance anion          |            |
|                      |                              |                      |                                                                                   | exchange chromatography                             |            |
| Black alder          | *Alnus glutinosa*            | Eurasia, Africa      | Betulin, betulonic acid, betulonic acid, lupeol                                    | Desorption atmospheric pressure                      | [12]       |
|                      | Betulaceae                   |                      |                                                                                   | photoionization (MS)                                |            |
| Alligator weed       | *Alternanthera philoxeroides*| South America        | Anthraquinone glycosides                                                          | Spectral analysis                                   | [13]       |
| Artillery plant      | *Lamium galeobdolon*         | Europe, Asia         | Volatile compounds                                                               | GC-MS                                              | [14]       |
| Ash                  | *Fraxinus excelsior*         | Europe, Asia         | Nodulisporiviridin M                                                              | ID, 2D 1H & 13C NMR                                 | [15]       |
| Asiatic knotweed     | *Fallopia japonica*          | Asia                 | Carotenoid                                                                       | HPTLC, HPLC-MS                                      | [16]       |
| Barberry             | *Berberis glaucocarpa*       | Himalayas            | Bisbenzylisoquinoline alkaloid, oxyacanthine                                     | 1D, 2D NMR                                         | [17]       |
| Blackberry           | *Rubus fruticosus*           | North temperate      | Polysaturated fatty acids                                                         | Supercritical carbon dioxide method                 | [18]       |
| Boxthorn             | *Lycium feroxissimum*        | South Africa         | Betaine                                                                          | Fast atom bombardment mass spectroscopy             | [19]       |
| Cape sundew          | *Drosera capensis*           | South Africa         | Jasmonic acid                                                                    | LC-MS/MS                                           | [20]       |
| Castor oil           | *Ricinus communis*           | Africa, Eurasia      | Ricin                                                                            | Spectral analysis                                   | [21]       |
| Century plant        | *Agave americana*            | Mexico               | Fructans                                                                         | Thermogravimetric analysis                          | [22]       |
| Cherry laurel        | *Prunus laurocerasus*        | South East Europe    | Cyanogentic glycosides, benzoic acid derivative                                   | LC-ESIMS                                            | [23]       |
| Chilean rhubarb      | *Gunnera tinctoria*          | South America        | Flavonoids                                                                        | HPLC-MS/MS                                          | [24]       |
| Chinese privet       | *Ligustrum sinense*          | China                | 10-hydroxy-oleuropein, 3-O-alpha-L-hamnopyranosyl-kaempherol-7-O-beta-D-gluco        | 1D, 2D NMR                                          | [25]       |
|                      | Oleaceae                     |                      | pyranoside                                                                        |                                                      |            |
| Evergreen buckthorn  | *Rhamnus alaternus*          | Mediterranean region | Anthraquinone glycosides                                                          | 1D, 2D NMR, FAB-MS                                  | [26]       |
| Giant hogweed        | *Heracleum mantegazzianum*   | Eurasia              | Essential oil                                                                     | GC-MS                                              | [27]       |
| Giant knotweed       | *Fallopia sachalinensis*      | Asia                 | Olymeric procyanidins, flavones, flavonoids                                      | GC-MS                                              | [28]       |
| Giant reed           | *Arundo donax*               | Eurasia              | Bis-indole alkaloid, phenylpropanoid                                              | Spectral analysis                                   | [29]       |
| Green cestrum        | *Cestrum parqui*             | Chile, Peru          | Saponin                                                                          | 1H, 13C NMR                                        | [30]       |
| Heather              | *Calluna vulgaris*           | Europe               | Catechin, epicatechin                                                             | HPLC-DAD-ESI/MS                                     | [31]       |
| Japanese honeysuckle | *Loniceria japonica*         | Japan                | Polysaccharides                                                                   | HPLC, FTIR                                         | [32]       |
| Khasia berry         | *Cotoneaster simonsii*        | China                | Tocopherols                                                                       | Spectral analysis                                   | [33]       |
| Kudzu vine           | *Pueraria lobata*             | Japan                | Lobatamunsolides A-C, nortignans                                                 | LC-MS                                              | [34]       |
| Loquat               | *Eriobotrya japonica*        | China, Japan         | Polysaccharides                                                                   | UMAE                                               | [35]       |
| Manchurian rice      | *Zizia latifolia*             | China                | Proanthocyanidins                                                                 | UAE                                                | [36]       |
| grass                 | *Poaceae*                    |                      |                                                                                   |                                                     |            |
| Mexican devil        | *Ageratina adenophora*       | South America        | Thymol derivatives                                                                 | 1H NMR, HR-ESI-MS, IR                              | [37]       |
### Table 3: A summary of pharmacological activities exhibited by weeds.

| Common name              | Botanical name                  | Native of                           | Reported pharmacological activity                        | Outcome of study                                                                 | Reference |
|--------------------------|---------------------------------|-------------------------------------|----------------------------------------------------------|----------------------------------------------------------------------------------|-----------|
| Aristea                  | Aristeae ecklonii              | West and South Africa               | Antimicrobial                                            | Plumbagin isolated from plant exhibited antimicrobial activities with MIC 2 μg/ml and 16 μg/ml | [50]      |
| Arrow bamboo             | Pseudosasa japonica           | Japan, South Korea                  | Antioxidant                                              | Leaves extract has potential to ameliorate oxidative stress by improving antioxidant activity | [51]      |
| Bear’s breeches          | Acanthus mollis               | South West Europe                   | Antioxidant, anti-inflammatory                           | Ethanol extract inhibited NO production                                         | [52]      |
| Blue spur flower         | Plectranthus ecklonii          | South Africa                        | Against pancreatic cancer                                | Antiproliferative effect was found to be effective against BxPC3, PANC-1, Ins1-E, HaCat, Caco-2 cell lines | [53]      |
| Buddleja                 | Buddleja davidii              | China                               | AChE inhibitory activity                                | Linarin isolated from plant inhibit AChE activity                               | [54]      |
| Cape honeysuckle         | Tecomania capensis             | South Africa                        | Analgesic, antipyretic, anti-inflammatory activities     | Methanolic extract of leaves significantly prevented increase in volume of paw edema | [55]      |
| Cat’s claw creeper       | Macfadyena unguis-cati         | Central and South America           | Anti-inflammatory, cytotoxic                             | Crude ethanol extract exhibited marked anti-inflammatory and cytotoxicity against lung cancer cell line | [56]      |
| Chocolate vine           | Akebia quinata Lardizalaceae   | China, Korea                        | Anti-fatigue agent                                       | Akebia extract showed marked improvement in lethargic behavioral test             | [57]      |
| Clematis                 | Clematis flammula              | Southern Europe and Northern Africa | Cytotoxic                                               | Weed extract cause kinases and transcription factor induction                     | [58]      |
| Climbing spindle berry   | Celastrus orbiculatus          | Eastern Asia, Korea, Japan, China   | Against gastric cancer                                   | Compound 28-hydroxy-3-oxoolean-12-en-29-oic acid inhibited the migration and invasion of gastric cancer cells | [59]      |
| Darwin’s barberry        | Berberis darwinii             | Chile, Argentina                    | Alzheimer’s disease                                      | Methanolic extract of stem bark exhibited acetycholinelastre inhibitory activity  | [60]      |
| Elder                    | Sambucus nigra Caprifoliaceae   | Europe, West Asia, North Africa     | Antioxidant                                              | Free radical scavenging potential                                                | [61]      |
| Elephant ear             | Alocasia brisanensis           | Ceylon, Tahiti                      | Antimicrobial                                            | Extract showed promising antimicrobial activities against Staphylococcus aureus   | [62]      |
| False acacia             | Robinia pseudoacacia           | South Eastern USA                   | Antilumor                                               | Inhibition of IL-1β signaling                                                    | [63]      |
| False tamarisk           | Myrcianthus germanica          | Eurasia                             | Cytotoxic                                               | Compound tamagerntin exhibited potent anti cancer effect                          | [64]      |
| Field horsetail          | Equisetum arvense              | Temperate Northern Hemisphere       | Antioxidant                                              | Potent antioxidant in DPPH assay                                                 | [65]      |
| Green daphne laurel      | Daphne laureola Thymelaeaceae  | North Africa, South West Europe     | Anticancer                                              | Cytotoxic against lung cancer                                                    | [66]      |
| Green goddess            | Zantedeschia aethiopica        | South Africa                        | Antimicrobial                                            | Peptides in weed exhibited antimicrobial activities                             | [67]      |
| Gipsywort                | Lycopus europaeus              | Europe, Asia                        | Antimicrobial                                            | Compound euroabienol showed broad spectrum activity                             | [68]      |
| Sp.                          | Family                      | Distribution                        | Effect                                                                 | Reference |
|------------------------------|-----------------------------|-------------------------------------|------------------------------------------------------------------------|-----------|
| Hop                          | Cannabaceae                 | Europe, Western Asia, North America | Osteogenic                                                             | [69]      |
| Homed poppy                  | Papaveraceae                | Western Europe, South Western Asia  | Against breast cancer                                                 | [70]      |
| Houttuynia                   | Saururaceae                 | Asia                                | Antiinflammatory                                                      | [71]      |
| Ivy                          | Araliaceae                  | Europe, North Africa                | Inhibition of Staphylococcus aureus strain                             | [72]      |
| Jerusalem cherry             | Solanaceae                  | South America                       | Acetylcholinesterase inhibitor                                        | [73]      |
| Lantana                      | Verbenaceae                 | Tropical America                    | Sedative                                                              | [74]      |
| Mexican water lily           | Nymphaeaceae                | Mexico                              | Antiinflammatory                                                      | [75]      |
| Nasturtium                   | Nymphaceae                  | Europe, America, Africa, Asia       | Antimicrobial                                                         | [76]      |
| Needlebrush                  | Proteaceae                  | Australia                           | Cytotoxic                                                             | [77]      |
| Old man's beard              | Clematis vitata             | Europe, South West Asia             | Antinoceptive and antipyretic                                        | [78]      |
| Pig's ear                    | Crassulaceae                | Africa                              | Anticonvulsant                                                        | [79]      |
| Pink ragwort                 | Asclepiadaceae              | South Africa                        | Cytotoxicity in HepG2 cells caused depletion of cellular GSH          | [80]      |
| Rough horsetail              | Equisetaceae                | Temperate Northern Hemisphere       | Antilyranosomosal                                                     | [81]      |
| Royal fern                   | Osmundaceae                 | Europe, India, Africa               | Inhibition of head and neck cancer cell proliferation                | [82]      |
| Tree privet                  | Oleaceae                    | China                               | Hepatocellular carcinoma                                             | [83]      |
| Tsutsan                      | Clusiaceae                  | South and Western Europe            | Anti-lipid peroxidation                                               | [84]      |
| Chingma lantern               | Malvaceae                   | North Western Africa                | Antiinfectious                                                        | [85]      |
| Black night shade            | Chenopodiaceae              | Eurasia                             | Hypoglycemic                                                          | [86]      |
| Broad leaved dock            | Polygonaceae                | Eurasia                             | Ethanol extract improved glucose tolerance in rabbits                 | [87]      |
| Broad leaved fleabane        | Asteraceae                  | South America                       | Antiplasmodial                                                        | [88]      |
| Broad leaved plantain        | Plantaginaceae              | Eurasia                             | Potential wound healer                                               | [89]      |
| Chick weed                   | Caryophyllaceae             | India                               | Antifungal                                                           | [90]      |
| Cleavers                     | Rubiaceae                   | Temperate zone                      | Immunomodulator                                                       | [91]      |
| Dandelion                    | Asteraceae                  | Africa                              | Extract from leaf provide protection against free radical mediated oxidative stress | [92]      |
| Father                       | Amaranthaceae               | Temperate zone                      | Antioxidant                                                          | [93]      |
| Galinsoga                    | Asteraceae                  | Tropical America                    | Photocarcinogenesis                                                   | [94]      |
| Hedge mustard                | Brassicaceae                | Southern Europe                     | Inhibition of oxidative mutagenicity                                 | [95]      |
| Hemlock                      | Apiaceae                    | Temperate region                    | Osteogenic                                                            | [96]      |
| Manuka                       | Myrtaceae                   | New Zealand, South East Australia   | Antibacterial                                                        | [97]      |
| Nettle                       | Ulricaceae                  | Europe                              | Anxiolytic                                                           | [98]      |
| Pennyroyal                   | Lamiaceae                   | Northern Africa                     | Antidiabetic                                                         | [99]      |
| Red dead nettle              | Lamiaceae                   | Eurasia                             | Haemostatic activity                                                 | [100]     |
| Scarlet pimpernel            | Primulaceae                 | Northern Africa                     | Aqueous leaf extract showed activity against Schistosoma mansoni      | [101]     |
| Scotch thistle               | Asteraceae                  | Europe                              | Hepatoprotective                                                     | [102]     |
| Scrambling speedwell         | Plantaginaceae              | Eurasia, America                     | Antiviral                                                            | [103]     |
### Antimicrobial weeds

Invasive weed *Aristea eklonii* containing Plumbagin exhibited antimicrobial activity with minimum inhibitory concentration between 2 μg/ml and 16 μg/ml [50]. Antimicrobial peptides isolated from arum lily (*Zantedeschia aethiopica*) exhibited potent antimicrobial activity [67]. Euroabienol (abietane-type diterpenoid) isolated from fruits of *Senecio latifolius* (*Bis (False acacia)* [63], *Robinia pseudoacacia* [64], *Senecio latifolius* (Pink ragwort) [80], *Osmanda regalis* (Royal fern) [82]. Parvifloron D isolated from *Plectranthus ecklonii* flash dry column chromatography exhibited antiproliferative effects against pancreatic cancer when evaluated against *HaCat, BxPC3, Caco-2, MCF-7, Ins1-E and PANC-1* cell lines [53].

Aqueous extract of weed *Solanum nigrum* at concentration of 10 g/l caused 43% cytotoxicity in MCF7 cell line by inhibiting migration, suppression of hexokinase and pyruvate kinase [86]. Triterpene (28-Hydroxy-3-oxoolean-12-en-29-oic acid) 10 g/l caused 43% cytotoxicity in *MCF7* cell line by inhibiting *Aqueous extract of weed HaCat, BxPC3, Caco-2, MCF-7, Ins1-E and PANC-1 cell lines* [53].

Flash dry column chromatography exhibited antiproliferative effects against pancreatic cancer when evaluated against *HaCat, BxPC3, Caco-2, MCF-7, Ins1-E and PANC-1 cell lines* [53].

### Antioxidant weeds

Strong antioxidant activity was reported by ferulic acid derived from leaves of weed *Pseudosa japonica* when evaluated using DPPH (54 %) and ABTS (65 %) [51]. Antioxidant potential of *Taraxacum officinale* was determined using in vitro methods (DPPH, ABTS, FRAP). The ABTS method revealed that antioxidant activity was 156±5.28 μg/ml [92]. Other potential antioxidant weed includes *Acanthus mollis* [52], *Sambucus nigra* [61], *Equisetum arvense* [65].

### Anti-inflammatory weeds

A study by Akhtar, et al. 2019 investigated the anti-inflammatory properties of *Hedera helix* and its major compounds on *Staphylococcus aureus* induced inflammation in mice. *Hedera* species-C isolated from weed exerted profound anti-inflammatory effects [72]. Mexican water lily (*Nymphaea mexicana*) was found to be potent COX-2 inhibitor [75]. Active compounds isolated from aerial parts of weed *Clematis vitalba* when evaluated in vivo against carrageenan, serotonin, PGE-2 induced hind paw edema showed antinoiceptive and antipyretic effects [78]. Methanolic extract of leaves of *Tecomaria capensis* significantly prevented increase in volume of paw edema [55]. Extract of *Persicaria hydropiper* exerted marked anti-inflammatory effects [106]. Aqueous extract alongwith compounds (calcereoside B, homoplantaginin, plantamajoside) isolated from the aerial parts of *Plantago major* showed inhibition against hyaluronidase enzyme [89].

### Antiviral weeds

Methanolic extract of scrambling speedwell weed (*Veronica persica*) reported potent activity against herpes simplex viruses and synergistic activity in combination with acyclovir anti-HSV therapy [103].

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**Figure 1: Therapeutic potential of weeds.**

| Weed Name          | Scientific Name                  | Family                  | Therapeutic Potential                                                                 |
|--------------------|----------------------------------|-------------------------|--------------------------------------------------------------------------------------|
| Selfheal           | Prunella vulgaris                | Lamiaceae               | Inhibition of IHNV infection, Ursolic acid decrease cytopathic effect and viral titer  |
| Sow thistle        | Sonchus oleraceus                | Asteraceae              | Inhibition of IHNV infection, Ursolic acid decrease cytopathic effect and viral titer  |
| Water pepper       | Persicaria hydropiper            | Polygonaceae            | Anti-inflammatory, Extract showed desired therapeutic effect                           |
| Yarrow             | Achillea millefolium             | Asteraceae              | Anti-inflammatory, Antiabesial activity, Different extract were active against *Brucella canis* |
| Woolly mullein     | Verbascum thapsus                | Scrophulariaceae        | Antimicrobial, Ethanolic extract were potent against gram positive bacteria           |
| Wild teasel        | Dipsacus fullonum                | Caprifoliaceae          | Antibacterial, Compounds isolated from root exhibited activity against *Staphylococcus aureus* |
| Cocklebur          | Xanthium strumarium              | Asteraceae              | Hepatocellular carcinoma, Weed induce apoptosis in HCC cell lines in a dose dependent manner |

Extracts obtained from leaves of weed *Abutilone theophrasti* elicited antimicrobial potential against *Staphylococcus aureus, Salmonella, Streptococcus* and *E. coli* species [85]. Essential oils isolated from weeds *Conium maculatum, Leptospermum scoparium* showed antimicrobial activity against several strains of *Pseudomonas aeruginosa* [96,97]. Ethanolic extracts of woolly mullein reported positive against gram positive bacteria (*Bacillus cereus*) [108]. Phenolic compounds from *Dipsacus fullonum* exerted inhibitory effects on *Staphylococcus aureus* DSM 799 and *E. coli* ATCC 10536 strains [109].

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**References:**

[58], [62], [52], [61], [65], [72], [51], [106], [75], [108], [89].
acid isolated form weed *Prunella vulgaris* inhibited HNV infection in aquaculture with an inhibitory concentration of 99.3 % at 100 mg/l [104].

**Weeds acting on CNS:** Methanolic extract of stem bark of darwin’s barberry (*Berberis darwinii*) inhibited acetylcholinesterase *in vitro* with IC₅₀ value of 1.23±0.05 microg/mL thereby provide relief in alzheimer’s disease [60]. Alkaloid solanocapsine isolated from weed *Solanum pseudocapsicum* reported to inhibit activity of enzyme acetylcholinesterase [73]. Nettle (*Urtica urens*) exhibited anxiolytic activity in mice when evaluated using hole board test, light-dark box test and rota rod test. Extract showed increased head-dip and head-dip counts in hole board test [98]. Aqueous (50-400 mg/kg i.p.) and methanol extracts (100-400 mg/kg i.p.) of Pig’s ear (*Cotyledon orbiculata*) exhibited anticonvulsant activity which predominantly delayed onset of seizures induced by N-methyl-dl-aspartic, bicuculline, picrotoxin in mice models [79].

**Other pharmacological activities of weeds:** Aqueous extract of *Akebia quinata* showed positive effect against fatigue in mice exposed to chronic restraint stress when evaluated using forced swimming behavioral test, sucrose preference and open field tests [57]. n-butanol fraction of weed *Equisetum hyemale* exerted antiprotozoal effects against *Trypanosoma evansi* tryptomastigotes after nine hours exposure [81]. Chen, et al. 2019 reported osteogenic activities of *Humulus lupulus* in MC3T3-E1 cell lines [69]. Ethanolic extract of weed *Galiaum aparine* stimulated the transformational activity of immunocompetent blood cells in vitro [91]. Aqueous extract of aerial parts of *Mentha pulegium* (20 mg/kg) showed antihyperglycemic effect by marked improvement in oral glucose tolerance test in streptozotocin induced diabetic rats [99]. Butanolic extracts of aerial parts of *Anagallis arvensis* (Scarlet pimpernel) were effective against *Babesia canis* parasite at 2 µl concentration [107].

**Other potential applications of weeds established in New Zealand**

A large number of weed communities has been reported to clean environment through phytoremediation process and act as bioindicators (Figure 2). Phytoremediation is described as a process of eradicating toxic contaminants from soil, water and air. This process involves phytostabilization (treating the environment [119], annual poa (*Poa annua*) have been involved in removing toxic metals (chromium, cadmium, zinc, lead) from the environment [119]. Parrot feather (*Myriophyllum aquaticum*) aids in removing antibiotic (tetracycline) from water [120]. Oxyeye daisy (*Leucanthemum vulgare*) potentiated crude oil phytoremediation and used in eliminating pollution from environment [121]. Apart from these properties weeds have also been found to be employed in other industries e.g. buffalo grass weed (*Stenotaphrum secundatum*) used in turf grass industry [122]. Mucoidhesive properties of water soluble gum obtained from *Hakea gibbos a* added in sustained release dosage forms [123]. Silver nanoparticles having average particle size 20 nm synthesized from *Cestrum nocturnum* showed more antioxidant potential as compared to vitamin C alongwith strong antibacterial activity against *Vibrio cholerae* with MIC of 16 μg/ml [124]. Organic fertilizer manufactured via aquatic weed *Salvinia molesta* when evaluated using FT-IR, plant bioassay test for determination of its fertilizer value and chemical composition showed promising results as vermicompost [125]. *Eragrostis species* (*E. capensis* and *E. curvula*) and grass *Stenotaphrum secundatum* exhibited drought resistant ability [126,127].

Besides the therapeutic potential exhibited by weeds, toxicity profile should be taken into consideration while exploring them. *Equisetum arvense* (Field horsetail) exerted hepatotoxicity in rats [128], weeds like *Zantedeschia aethiopica* (Arum lily), *Conium maculatum* (Hemlock), *Solanum nigrum* (Black night shade) are considered poisonous in New Zealand.

![Figure 2: An overview of Phytoremediation process.](https://doi.org/10.29328/journal.jpsp.1001050)
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[129]. *Hedera helix* (Ivy) caused contact dermatitis [130], *Lantana camara* exerted in vivo cell toxicity [131], *Xanthium strumarium* (Cocklebur) responsible for causing poisoning in cattle [132].

**Conclusion**

Humans define weeds as per their appropriateness and understanding of the plant. A plant investigated as weed in some region may be a plant of medicinal importance for another region. The usefulness of weeds has been ignored by humans for long time because of their invasive growth, competitors of genuine crop and no economic value. This human behaviour might be developed over time due to lack of proper knowledge of phytochemical screening as well as therapeutic potential of weeds. Weeds are the sources of human food, fodder in agriculture, shelter for some animals, helpful against soil erosion, indicators of soil nutrients, as well as sources of commercially important essential oils. In this era weeds have been extensively explored for their immense phytopharmacological prospects. It is evidenced that weeds have been sources of potential targets for different pathological conditions. However there is need of more scientific and clinical investigations required in assessment of toxicity profile to get the maximum potential of weeds. Weeds have protective role in environment as a component of phytoremediation and for sustainable ecosystem. Because of immense therapeutic potential implicit by weeds a new chain of thoughts emerge in our mind to consider the value of these important plants so called 'weeds'. Are they need to be redefined or we need to rethink the concept of weeds? It is clear from the studies documented in this review that the approach of whether a plant is wanted or not should depends on its pharmacological potential and role in ecosystem other than merely the competitive effect of plant with the particular crop. Further advancements are required in order to spin the concept of weeds into therapeutic weeds.

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