PRINT: ISSN 0973-5070 ONLINE: ISSN 2456-6772
Ethno Med, 14(1-2): 1-8 (2020)
DOI: 10.31901/24566772.2020/14.1-2.597

Medicinal Plants Used for the Treatment of Respiratory Diseases in Uttarakhand State of India

Chandra Prakash Kala

Ecosystem & Environment Management, Indian Institute of Forest Management, Nehru Nagar, Bhopal 462 003, Madhya Pradesh, India
E-mail: cpkala@yahoo.co.uk

KEYWORDS Air Pollution. Herbal Healers. Himalaya. Ethnomedicine. Traditional Knowledge

ABSTRACT Respiratory diseases in human beings are on rise, at present, due to many reasons including deteriorating air quality. Traditionally, plants are used to treat respiratory diseases. The present study, therefore, aims to identify and document plant use for treatment of respiratory diseases in Uttarakhand state of India. Interviews with local herbal healers resulted in documentation of 82 plant species as they were used to treat 7 types of respiratory diseases such as asthma, bronchitis, tuberculosis, pneumonia, influenza, lung disorder and cough and cold. The highest number of species (n=57) was documented for treatment of cough and cold, followed by asthma (n=27) and bronchitis (n=20). *Aconitum heterophyllum*, *Ocimum sanctum*, *Punica granatum*, *Terminalia bellirica* and *Zingiber officinale* were frequently used plants to treat cough and cold. These plant species if tested clinically it may open new avenues for making new drugs to treat various respiratory diseases.

INTRODUCTION

The respiratory tract in humans, which include trachea, bronchi, bronchioles, alveoli, pleura, pleural cavity, nerves, muscles and lungs, afflicts with various types of diseases. Altogether, all these diseases are placed under the category of respiratory diseases, which range from common cold - a mild ailment - to life threatening ailments such as pneumonia, tuberculosis and asthma. Worldwide, a large number of people suffer from respiratory diseases, of which 300 million alone suffer from life threatening asthma and about 250,000 people died of this alarming disease in 2005 (WHO 2008). Respiratory diseases are on rise due to many reasons including poor air quality, especially in urban areas (Kelly 2003; D'Amato et al. 2014). Inhaling contaminated air increases number of patients having respiratory diseases. Smoking and poor hygienic conditions do invite respiratory diseases (Azarpazhooh and Leake 2006; López Campos et al. 2015). The American Association for the Advancement of Science reports that 5.5 million people died worldwide in 2013 due to air pollution, of which 1.4 million deaths occurred in India (Biswas and Hartley 2016).

Despite commendable achievements in the medical science, respiratory diseases still tempt to morbidity and mortality (Suroowan and Mahomoodally 2016). In developing countries like India the respiratory diseases are quite common due to many reasons. Smoking, which affects the respiratory system, causes about 700,000 deaths per year in India (Gajalakshmi et al. 2003). Due to unhygienic conditions the non-smokers such as children aged less than 5 years are also subjected to respiratory tract infections. Every year over 700 million episodes of acute respiratory infections and over 52 million episodes of pneumonia are known to affect the children below 5 years age in India, of which more than 400,000 die due to pneumonia (Selvaraj et al. 2014).

Traditionally, the local medical practitioners have been treating different respiratory diseases, which include asthma, pneumonia, cough and cold by using plants. Since a large section of the society, especially in the developing countries, still uses traditional medicines as the first safety measure in the healthcare (Kala et al. 2006; Bhasin 2008), the World Health Organization has recognized the importance of traditional health care systems (Goleniowski et al. 2006). The knowledge created by the traditional herbal healers over the centuries of experimentation needs to be documented in view of its historical importance for treating various respiratory diseases. The present study, therefore, was conducted in Uttarakhand state of India with a view to understand the uses of plant species for treating various respiratory diseases. The primary aim of

this study is to document the medicinal plant species used by local people and the herbal healers for curing respiratory diseases.

METHODOLOGY

Study Area

The present study was conducted in the Indian state of Uttarakhand, which lies between 28^0 43' to 31^0 8' N and 77^0 35' to 81^0 2' E. Uttarakhand state possesses a wide altitudinal range from 210 m to 7,817 m over the total area of 53,485 km^2. It comprises of 13 districts inhabited by 10,116,752 people according to the 2011 Census of India. The state is well-known for its biological and cultural diversity (Kala 2018). It holds diverse forests along the altitudinal gradient, which include sub-tropical, temperate and sub-alpine forests. The areas above sub-alpine forests are predominated by herbaceous species. Most of the geographical area of the state spans over hills therefore it has remained isolated from rest of the agricultural plains of northern India and has thus preserved some of the old practices, traditions and ethnic norms for various resource use patterns (Kala 2011, 2019). The state being a pilgrimage centre for Hindus and Sikhs, it owns the reputation as the Devbhumi - Land of the Gods. Besides, various ethnic groups including Bhotiya, Tharu, Buksa, Jaunsari and Raji live in the state (Kala 2010). Traditionally, Bhotia, Raji and Jaunsari live in higher elevation ranges of the state whereas Tharu and Buksa generally live in the foothills and the Terai region or plains. The rich plant and cultural diversity, geographical isolation and long period of people dependency on plants for curing diseases are some of the important factors for selection of Uttarakhand to carry out the present study.

Survey Methods

Secondary Sources

The extensive literature survey (including CSIR 1989; Jain 1991; Kala 2005, 2006, 2010, 2013, 2015; Nautiyal et al. 2001; Kala and Ratajc 2012; Gaur 1999; Phondani et al. 2010; Semwal et al. 2010) was carried out for the compilation of medicinal plant species used to treat different types of respiratory diseases by the local people and the herbal healers of Uttarakhand. Different plant parts used to treat respiratory diseases were compiled along with the number of plant species used to treat number of respiratory diseases.

Fieldwork

Apart from gathering of data from secondary sources, field surveys were also undertaken in various villages and forest areas of Uttarakhand for collection of information on the availability and uses of medicinal plant species. The structured questionnaire survey was conducted for the purpose of gathering data on the types of ailments being cured by healers with the help of medicinal plants and plant parts. The information on respiratory diseases and their treatments was gathered from 60 traditional herbal healers while documenting various uses of medicinal plants. Five workshops were also organized in different districts of Uttarakhand and various groups of indigenous people including herbal healers were invited to interact and help in documentation of their knowledge on medicinal plants for curing diseases. The data was cross checked by interviewing more than three healers on the specific uses of a plant species. In order to verify the identity of medicinal plant species field visits were undertaken with herbal healers and knowledgeable persons.

RESULTS

A large number of medicinal plant species growing in different altitudes and localities of Uttarakhand are used to treat various respiratory diseases. The present study documented 82 plant species of which herbaceous plant species were highest (n=47), followed by trees and shrubs (15 in each life form; Table 1). These 82 species were distributed across 44 families, of which Ranunculaceae, Liliaceae, Lamiaceae and Asteraceae were the most dominant families in terms of number of species (n=4). Contrary to this, 23 plant families contain only single species. Different plant parts such as leaf, root, fruit, flower, seed, stem, bark and latex were used for the treatment of respiratory diseases. The underground plant parts such as root and modified stems such as rhizome, bulb and tuber of majority of species were used.

Table 1: Medicinal plants and plant parts used for treating respiratory diseases in Uttarakhand state of India

S. No.	*Species*	*Family*	*Life form*	*Plant part used*
1	*Abies pindrow* Royle	Pinaceae	Tree	Bark
2	*Abies spectabilis* (D. Don) Mirbel	Pinaceae	Tree	Leaf, bark
3	*Abrus precatorius* L.	Fabaceae	Woody climber	Seed, root
4	*Achillea millefolium* L.	Asteraceae	Herb	Whole plant
5	*Aconitum heterophyllum* Wall.	Ranunculaceae	Herb	Root
6	*Acorus calamus* L.	Aracease	Herb	Root
7	*Adhatoda zeylanica* Medikus	Acanthaceae	Shrub	Leaf, flower
8	*Allium cepa* L.	Liliaceae	Herb	Bulb
9	*A. sativum* L.	Liliaceae	Herb	Bulb
10	*Anemone rivularis* Buch.-Ham. ex DC.	Ranunculaceae	Herb	Whole plant
11	*Anogeissus latifolia* Bedd.	Combretaceae	Tree	Bark
12	*Asclepias curassavica* L.	Asclepiadaceae	Shrub	Leaf
13	*Aster asteroids* DC.	Asteraceae	Herb	Root
14	*Astragalus candolleanus* Royle ex Benth.	Fabaceae	Shrub	Root
15	*Bauhinia variegata* L.	Caesalpiniaceae	Tree	Bark, leaf
16	*Bergenia ciliata* (Haworth) Sternb.	Saxifragaceae	Herb	Root, leaf
17	*Butea monosperma* (Lamk.) Kuntze	Fabaceae	Tree	Flower, bark, seed
18	*Calotropis procera* (Aiton) Dryander	Asclepiadaceae	Shrub	Flower
19	*Cannabis sativa* L.	Cannabinaceae	Herb	Leaf, seed
20	*Carissa opeca* Stapf.	Apocynaceae	Shrub	Leaf
21	*Carum carvi* L.	Apiaceae	Herb	Seed
22	*Centella asiatica* (L.) Urban	Apiaceae	Herb	Flower, leaf, root
23	*Cerastium cerastoides* (L.) Britt.	Caryophyllaceae	Herb	Whole plant
24	*Cinnamomum zeylanicum* Nees	Lauraceae	Tree	Leaf, bark
25	*Cissampelos pareira* L.	Menispermaceae	Climber herb	Leaf, root
26	*Clematis montana* Buch.-Ham. ex DC.	Ranunculaceae	Woody climber	Root
27	*Cuscuta reflexa* Roxb.	Convolvulaceae	Climber herb	Whole plant
28	*Cyanoglossum zeylanicum* (Vehl ex Hornem.) Thunb. ex Lehmann	Boraginaceae	Herb	Leaf, root
29	*Datura stramonium* L.	Solanaceae	Shrub	Leaf, root
30	*Doronicum roylei* DC.	Asteraceae	Herb	Root
31	*Ephedra gerardiana* Wall.	Ephedraceae	Shrub	Root, Stem
32	*Eulophia dabia* (D. Don) Hoch.	Orchidaceae	Herb	Tuber
33	*Euphorbia hirta* L.	Euphorbiaceae	Herb	Whole plant
34	*Ficus benghalensis* L.	Moraceae	Tree	Latex
35	*F. racemosa* L.	Moraceae	Tree	Bark, fruit, latex
36	*F. religiosa* L.	Moraceae	Tree	Leaf, bark, fruit
37	*Fritillaria roylei* Hk.	Liliaceae	Herb	Bulb
38	*Galium elegans* Wall.	Rubiaceae	Herb	Shoot
39	*Gentianella moorcroftiana* (Wall. ex Griseb.) Airy-Shaw	Gentianaceae	Herb	Whole plant
40	*Gloriosa superba* L.	Liliaceae	Herb	Root, leaf
41	*Hedychium spicatum* Ham. ex Smith	Zingiberaceae	Herb	Rhizome
42	*Lomatogonium carinthiacum* (Wulf.) Br.	Gentianaceae	Herb	Whole plant
43	*Malva verticillata* L.	Malvaceae	Herb	Leaf, root
44	*Myrica esculenta* Buch.-Ham. ex D. Don	Myricaceae	Tree	Bark, fruit
45	*Nardostachys jatamansi* (D. Don) DC.	Valerianaceae	Herb	Rhizome
46	*Nepeta glutinosa* Benth.	Lamiaceae	Herb	Whole plant
47	*Ocimum sanctum* L.	Lamiaceae	Herb	Whole plant
48	*Origanum vulgare* L.	Lamiaceae	Herb	Whole plant
49	*Oxalis corniculata* L.	Oxalidaceae	Herb	Leaf
50	*Picrorhiza kurrooa* Benth	Scrophulariaceae	Herb	Root
51	*Podophyllum hexandrum* Royle	Podophyllaceae	Herb	Rhizome, fruit
52	*Polygonum amplexicaule* Don	Polygonaceae	Herb	Root
53	*P. viviparum* L.	Polygonaceae	Herb	Root
54	*Prunella vulgaris* L.	Lamiaceae	Herb	Whole plant
55	*Punica granatum* L.	Punicaceae	Tree	Stem, fruit cover

Table 1: Contd...

S. No.	*Species*	*Family*	*Life form*	*Plant part used*
56	*Ranunculus arvensis* L.	Ranunculaceae	Herb	Leaf
57	*Rheum australe* Don.	Polygonaceae	Herb	Root, leaf
58	*Rhododendron anthopogon* Don	Ericaceae	Shrub	Leaf
59	*R. campanulatum* Don	Ericaceae	Shrub	Root, leaf
60	*Ricinus communis* L.	Euphorbiaceae	Shrub	Seed, leaf
61	*Saussurea costus* (Falc.) Lipsch.	Asteraceae	Herb	Root
62	*Selinum candollii* DC.	Apiaceae	Herb	Root
63	*Silene vulgaris* (Moench) Garcke	Caryophyllaceae	Herb	Leaf
64	*Solanum nigrum* L.	Solanaceae	Herb	Fruit, leaf, seed
65	*Stephania glabra* (Roxb.) Miers	Menispermaceae	Climber herb	Tuber
66	*Swertia chiraiyta* (Roxb. ex Fleming) Karsten	Gentianaceae	Herb	Whole plant
67	*Terminalia bellirica* (Gaertner) Roxb.	Combretaceae	Tree	Fruit
68	*Terminalia chebula* Retx.	Combretaceae	Tree	Fruit, seed
69	*Tinospora cordifolia* L.	Menispermaceae	Herb	Whole plant
70	*Toona ciliata* Roem.	Meliaceae	Tree	Bark, fruit, leaf
71	*Trianthema portulacastrum* L.	Aizoaceae	Herb	Root
72	*Tylophora indica* (Burm. f.) Merr.	Asclepiadaceae	Shrub	Whole plant
73	*Verbascum thapsus* L.	Schrophulariaceae	Herb	Whole plant
74	*Viola bioflora* L.	Violaceae	Herb	Flower, leaf
75	*V. canescens* Wall.	Violaceae	Herb	Leaf, flower
76	*V. pilosa* Blume	Violaceae	Herb	Whole plant
77	*Vitex negundo* L.	Verbenaceae	Shrub	Stem, flower, leaf
78	*Woodfordia fruticosa* (L.) Kurz.	Lythraceae	Shrub	Flower
79	*Zanthoxylum armatum* DC.	Rutaceae	Shrub	Fruit, stem, bark
80	*Zingiber officinale* Roscoe	Zingiberaceae	Herb	Rhizome
81	*Ziziphus mauritiana* Lam.	Rhamnaceae	Tree	Fruit
82	*Ziziphus nummularia* (Burn. F.) Wight and Arn.	Rhamnaceae	Shrub	Rhizome

Species were used for treating 7 major types of respiratory diseases including asthma, bronchitis, tuberculosis, pneumonia, influenza, lung disorder and cough and cold (Table 2). Most of the species were used for treating a limited number of respiratory diseases. *Acorus calamus* was used for the treatment of 3 types of respiratory diseases. *Adhatoda zeylanica, Zingiber officinale, Abies pindrow, Swertia chiraiyta* and *Abies spectabilis* were other important species in their uses. Among the different respiratory diseases, the highest number of species (n=57) was documented for treating cough and cold, followed by asthma (n=27), bronchitis (n=20), tuberculosis (n=5), pneumonia (n=5) and influenza (n=3).

Of the 82 medicinal plant species used for the treatment of respiratory diseases, the following 13 are considered rare and endangered: *Aconitum heterophyllum, Gloriosa superba, Nardostachys jatamansi, Ephedra gerardiana, Rheum australe, Fritillaria roylei, Podophyllum hexandrum, Picrorhiza kurrooa, Rhododendron anthopogon, R. campanulatum, Swertia chiraiyta, Saussurea costus* and *Zanthoxylum armatum*. Of these 13 plant species, four species (*Aconitum heterophyllum, Nardostachys jatamansi, Picrorhiza kurrooa* and *Saussurea costus*) are in the critically endangered category; four species (*Ephedra gerardiana, Rheum australe, Fritillaria roylei* and *Podophyllum hexandrum*) in the endangered category; two species (*Zanthoxylum armatum* and *Gloriosa superba*) in the vulnerable category, and *Rhododendron anthopogon* and *R. campanulatum* in the near threatened category as per the IUCN red list categories.

DISCUSSION

Uttarakhand state of India is known for having a high diversity of medicinal plants. The present investigation results into documentation of highest number of medicinal plants for curing cough and cold. Most of the geographical area in the state being hilly the severe cool climatic condition invites cold related ailments

Table 2: Plant species used for the treatment of different types of respiratory diseases in Uttarakhand state of India

S. No.	*Respiratory diseases*	*Number of plants used*	*Name of plant species*
1	Cough and cold	57	*Abies pindrow, Abrus precatorius, Achillea millefolium, Aconitum heterophyllum, Acorus calamus, Adhatoda zeylanica, Allium sativum, Anemone rivularis, Anogeissus latifolia, Asclepias curassavica, Astragalus candolleanus, Bauhinia variegata, Calotropis procera, Cannabis sativa, Carissa opeca, Carum carvi, Centella asiatica, Cerastium cerastoides, Cinnamomum zeylanicum, Cissampelos pareira, Clematis montana, Cuscuta reflexa, Cyanoglossum zeylanicum, Doronicum roylei, Eulophia dabia, Euphorbia hirta, Ficus bengalensis, F. religiosa, Gentianella moorcroftiana, Lomatogonium carinthiacum, Malva verticillata, Myrica esculenta, Nardostachys jatamansi, Ocimum sanctum, Origanum vulgare, Oxalis corniculata, Picrorhiza kurrooa, Podophyllaum hexandrum, Polygonum amplexicaule, Prunella vulgaris, Punica granatum, Rhododendron anthopogon, Rhododendron campanulatum, Selinum candollii, Solanum nigrum, Terminalia bellirica, Terminalia chebula, Verbascum thapsus, Viola bioflora, V. canescens, V. pilosa, Vitex negundo, Woodfordia fruticosa, Zanthoxylum armatum, Zingiber officinale, Ziziphus mauritiana, Ziziphus nummularia*
2	Asthma	27	*Abies spectabilis, Acorus calamus, Allium cepa, Calotropis procera,Cyanoglossum zeylanicum, Datura stramonium, Ephedra gerardiana, Euphorbia hirta, Ficus religiosa, Fritillaria roylei, Gloriosa superba, Hedychium spicatum, Myrica esculenta, Picrorhiza kurrooa, Ranunculus arvensis, Rheum australe, Saussurea costus, Selinum candollii, Silene vulgaris, Stephania glabra, Swertia chiraiyta, Tinospora cordifolia, Terminalia bellirica, Trianthema portulacastrum, Tylophora indica, Verbascum thapsus, Viola canescens*
3	Bronchitis	20	*Abies pindrow, Abies spectabilis, Acorus calamus, Adhatoda zeylanica, Allium cepa, Cannabis sativa, Euphorbia hirta, Ficus racemosa, Fritillaria roylei, Galium elegans, Hedychium spicatum, Nardostachys jatamansi, Ocimum sanctum, Rheum australe, Rhododendron anthopogon, Silene vulgaris, Swertia chiraiyta, Terminalia chebula, Viola canescens, Toona ciliata*
4	Tuberculosis	5	*Bergenia ciliata, Butea monosperma, Centella asiatica, Stephania glabra, Zingiber officinale*
5	Pneumonia	5	*Ficus racemosa, Nepeta glutinosa, Ricinus communis, Terminalia chebula, Vitex negundo*
6	Influenza	3	*Origanum vulgare, Picrorhiza kurrooa, Swertia chiraiyta*
7	Lung disorder	2	*Polygonum viviparum, Prunella vulgaris*

in humans for major part of the year. The traditional medicinal practitioners, therefore, would have attempted to find out herbs that could cure cold related disorders. Out of 57 plant species documented for curing cough and cold, *Aconitum heterophyllum, Adhatoda zeylanica, Anemone rivularis*, *Cinnamomum zeylanicum, Nardostachys jatamansi, Ocimum sanctum, Punica granatum, Terminalia bellirica, Terminalia chebula, Zanthoxylum armatum* and *Zingiber officinale* are frequently used by the local people, even without consulting specialized herbal prac-

titioners. The rind of pomegranate, both leathery exocarp and fleshy mesocarp, is stored for months after sun drying. The dried rind is roasted on mild fire and then chewed for curing cough. Similarly, the rhizome of *Zingiber officinale* is roasted and then chewed. The leaves of *Ocimum sanctum* are consumed either raw or as a drink by making its tea, especially for the treatment of cough and cold.

Different parts of plants are used to prepare medicine for treatment of diseases, however whole plant of 16 species (all are herbs) is used to treat respiratory diseases. These species include *Anemone rivularis, Cuscuta reflexa, Euphorbia hirta, Gentianella moorcroftiana, Lomatogonium carinthiacum, Ocimum sanctum, Prunella vulgaris, Tinospora cordifolia, Verbascum thapsus, Viola pilosa* and endangered *Swertia chiraiyta*. Over 23 plant species are uprooted as their roots and rhizomes are used to treat diseases, which include four critically endangered species (i.e., *Aconitum heterophyllum, Saussurea costus, Picrorhiza kurrooa* and *Nardostachys jatamansi*), two endangered species (e.g., *Ephedra gerardiana* and *Rheum australe*), and one vulnerable species namely *Gloriosa superba*. Harvesting of roots and rhizomes of such threatened species may mount extra pressure on their already limited populations.

Studies conducted elsewhere have reported plants use for the treatment of respiratory diseases. Inhabitants of Lövéte and Nagybacon villages of Transylvanian farms in Romania use 34 and 26 species of medicinal plants respectively to treat respiratory diseases (Papp et al. 2011). An ethnopharmacological analysis of traditional medicine documents 55 plant species those are used to treat 18 respiratory tract diseases in Mauritius where 81 different recipes are concocted by using these plants and oral intake is the most common route of administration (Suroowan and Mahomoodally 2016). In Urmia City, which is located in the west Azarbaijan Province of Iran, the local people use 20 medicinal plant species to treat respiratory disorders, traditionally (Asadbeigi et al. 2014). The use of plants for treating diseases is common in different provinces of Iran (Ghasemi-Pirbalouti 2013; Asadbeigi et al. 2014). In Uttarakhand, the leaves and roots of maximum number of plants are used however contrary to the present study, the people of Urmia use seeds of maximum number of species to treat respiratory diseases.

In northwest region of Cameroon where the altitude ranges from 950 to 1500 m above mean sea level, the local people use over 54 plant species to treat 9 types of respiratory diseases, including asthma, bronchitis, cough, pneumonia, cold and tuberculosis (Focho et al. 2009). Likewise present study, leaf is the most frequently used plant part in Cameroon which is attributed to the ability of leaf to form and store variety of medicinally useful chemical compounds through photosynthesis (Ramesh and Okigbo 2008). In KwaZulu-Natal of South Africa, over 30 plant species are used to treat respiratory diseases by the rural people by making decoctions of these plants, which is mostly taken orally along with combination of steaming (York et al. 2011).

Twenty-two plants used in Mexican traditional medicine to treat respiratory diseases when evaluated clinically for their activity against tuberculosis the *Lantana hispida* was emerged as an important source of potential compounds against tuberculosis (Jimenez Arellanes et al. 2003). A few plant species such as *Allium sativum* and *A. cepa* documented during the present investigation are clinically tested for their efficacy (Gupta et al. 2010), which renders very satisfactory results. This shows that medicinal plants offer a hope for developing alternate medicines for the treatment of various respiratory diseases. The present list of 82 plants is anticipated to open new avenues for making new drugs that can help to reduce sufferings of human beings.

At present, the level of toxic substances is increasing in the atmosphere, which is deteriorating the air quality. Around 300 million children live in areas where outdoor air pollution exceeds 6 times higher than international guidelines that is caused by heavy use of fossil fuels, vehicle emissions, construction, and burning of waste and seasonal stubble (UNICEF 2016). During and immediately after some of the festivals such as Diwali in India, due to intense use of firecrackers the concentration of air pollutants such as carbon monoxide, carbon dioxide, and lead increases manifold, which affects the respiratory system of people living in the immediate surroundings. Besides Diwali, Uttarakhand has the history of regular forest fire due to pre-

dominance of chir pine (*Pinus roxburghii*) forest between 600-2300 m, which makes the air quality quite hazardous for its inhabitants, especially during such incidences. Therefore, apart from drawing preventive measures to keep the air clean and to discourage use of tobacco, the use of medicinal plants may help the affected communities in the areas reeling under the present pressure of air and air related pollutions.

CONCLUSION

The local people of Uttarakhand possess rich knowledge on use of plant species for treatment of various respiratory diseases. Some plant species are prominent as they are used frequently for treatment of multiple respiratory disorders. On the other hand, there are rare and endangered species used as medicines by the local people. The traditional knowledge on medicinal plants, as documented during the present study, can be used for carrying out further scientific research in order to validate and standardize the medicinal efficacy of such important plant species. Moreover, the importance of such studies and plant species has increased several folds, at present, when the air quality has become extremely substandard for the survival of human beings.

ACKNOWLEDGEMENT

Author thanks herbal healers of Uttarakhand for their help and valuable support during the course of this study.

REFERENCES

Asadbeigi M, Mohammadi T, Rafieian-Kopaei M, Saki K, Bahmani M, Delfan M 2014. Traditional effects of medicinal plants in the treatment of respiratory diseases and disorders: An ethnobotanical study in the Urmia. *Asian Pacific Journal of Tropical Medicine*, 7: 364-368.

Azarpazhooh A, Leake JL 2006. Systematic review of the association between respiratory diseases and oral health. *Journal of Periodontology,* 77(9): 1465-1482. doi:10.1902/jop.2006.060010

Bhasin V 2008. Gaddi's folk medicine: A source of healing. *Studies on Ethno-Medicine,* 2 (1): 1-27.

Biswas AK, Hartley K 2016. Foul Odour of Failure. *Times of India*, 8 November 2016.

CSIR 1989. *The Wealth of India: Raw Materials.* Publications & Information Directorate, Council of Scientific and Industrial Research, New Delhi.

D'Amato G, Cecchi L, D'Amato M, Annesi-Maesano I 2014. Climate change and respiratory diseases. *European Respiratory Review,* 23(132): 161-169.

Focho DA, Nkeng EAP, Fonge BA, Fongod AN, Muh CN, Ndam TW, Afegenui A 2009. Diversity of plants used to treat respiratory diseases in Tubah, northwest region, Cameroon. *African Journal of Pharmacy and Pharmacology,* 3(11): 573-580.

Gajalakshmi V, Peto R, Kanaka TS, Jha P 2003. Smoking and mortality from tuberculosis and other diseases in India: retrospective study of 43000 adult male deaths and 35000 controls. *The Lancet,* 362 (9383): 507-515.

Gaur RD 1999. *Flora of the District Garhwal Northwest Himalaya (With Ethnobotanical Notes).* TransMedia, Srinagar Garhwal, India.

Ghasemi-Pirbalouti A, Momeni M, Bahmani M 2013. Ethnobotanical study of medicinal plants used by Kurd tribe in Dehloran and Abdanan districts, Ilam Province, Iran. *African Journal of Tradition, Complementary and Alternative Medicine,* 10(2): 368-385.

Goleniowski ME, Bongiovanni GA, Bongiovanni L, Palacio CO, Cantero JJ 2006. Medicinal plants from the "Sierra de Comechingones". *Argentina Journal of Ethnopharmacology,* 107(3): 324–341.

Gupta R, Thakur B, Singh P, Singh HB, Sharma VD, Katoch VM, Chauhan SVS 2010. Anti-tuberculosis activity of selected medicinal plants against multidrug resistant Mycobacterium tuberculosis isolates. *Indian Journal of Medical Research,* 131(6): 809-813.

Jain SK 1991. *Dictionary of Indian Folk Medicine and Ethnobotnay.* New Delhi Deep Publications.

Jimenez Arellanes A, Meckes M, Ramirez R, Torres J, Luna Herrera J 2003. Activity against multidrug resistant Mycobacterium tuberculosis in Mexican plants used to treat respiratory diseases. *Phytotherapy Research,* 17(8): 903-908.

Kala CP 2005. Current status of medicinal plants used by traditional Vaidyas in Uttaranchal state of India. *Ethnobotany Research and Applications,* 3: 267-278.

Kala CP 2006. Preserving Ayurvedic herbal formulations by Vaidyas: The traditional healers of the Uttaranchal Himalaya region in India. *HerbalGram,* 70: 42-50.

Kala CP 2010. *Medicinal Plants of Uttarakhand: Diversity, Livelihood and Conservation.* Delhi, India: Biotech Books.

Kala CP 2011. Medicinal plants used for dermatological disorders: a study of Uttarakhand state in India. *Australian Journal of Medical Herbalism,* 23(3): 132-137.

Kala CP 2013. Indigenous knowledge, use of NTFPs and biodiversity conservation in Uttarakhand. In: CP Kala, CS Silori (Eds.): *Biodiversity, Communities and Climate Change*. New Delhi: The Energy and Resources Institute, pp. 245-255.

Kala CP 2015. Medicinal and aromatic plants of tons watershed in Uttarakhand Himalaya. *Applied Ecology and Environmental Sciences,* 3(1): 16-21.

Kala CP 2018. Uses, population status and management of Betula utilis. *Applied Ecology and Environmental Sciences*, 6(3): 79-83.

Kala CP 2019. Medicinal plants used for treatment of fever and headache in Uttarakhand state of India. *Journal of Non-Timber Forest Products*, 26(1): 39-44.

Kala CP, Dhyani PP, Sajwan BS 2006. Developing the medicinal plants sector in northern India: Challenges and opportunities. *Journal of Ethnobiology and Ethnomedicine*, 2: 32. DOI: 10.1186/1746-4269-2-32.

Kala CP, Ratajc P 2012. High altitude biodiversity of the Alps and the Himalayas: Ethnobotany, plant distribution and conservation perspective. *Biodiversity and Conservation*, 21(4): 1115-1126.

Kelly FJ 2003. Oxidative stress: its role in air pollution and adverse health effects. *Occupational and Environmental Medicine*, 60(8): 612-616.

López Campos JL, Tan W, Soriano JB 2015. Global burden of COPD. *Respirology*, 21 (1): 14-23.

Nautiyal S, Maikhuri RK, Rao KS, Saxena KG 2001. Medicinal plant resources in Nanda Devi Biosphere Reserve in the central Himalayas. *Journal of Herbs, Spices & Medicinal Plants*, 8(4): 47-64.

Papp N, Bartha S, Boris G, Balogh L 2011. Traditional uses of medicinal plants for respiratory diseases in Transylvania. *Natural Product Communications*, 6(10): 1459-1460.

Phondani PC, Maikhuri RK, Rawat LS, Farooquee NA, Kala CP, Vishvakarma SCR, Rao KS, Saxena KG 2010. Ethnobotanical Uses of Plants among the Bhotiya Tribal Communities of Niti Valley in Central Himalaya, India. *Ethnobotany Research and Applications*, 8: 233-244.

Ramesh P, Okigbo RN 2008. Effects of medicinal plant combinations as anti-infectives. *African Journal of Pharmacy and Pharmacology*, 2(7): 130-135.

Selvaraj K, Chinnakali P, Majumdar A, Krishnan IS 2014. Acute respiratory infections among under-5 children in India: A situational analysis. *Journal of Natural Science, Biology and Medicine*, 5(1): 15–20. doi: 10.4103/0976-9668.127275

Semwal DP, Saradhi PP, Kala CP, Sajwan BS 2010. Medicinal plants used by local vaidyas in Ukhimath block, Uttarakhand. *Indian Journal of Traditional Knowledge*, 9(3): 480-485.

Suroowan S, Mahomoodally MF 2016. A comparative ethnopharmacological analysis of traditional medicine used against respiratory tract diseases in Mauritius. *Journal of Ethnopharmacology*, 177: 61-80.

UNICEF 2016. Clear the Air for Children: The Impact of Air Pollution on Children. United Nations Children's Fund. From<http://www.unicef.org/publications/files/UNICEF_Clear_ the_Air_ for_Children_30_Oct_2016.pdf>.

WHO 2008. *Global Alliance Against Chronic Respiratory Diseases Action Plan 2008-2013.* World Health Organization, Geneva, Switzerland.

York T, De Wet H, Van Vuuren SF 2011. Plants used for treating respiratory infections in rural Maputaland, KwaZulu-Natal, South Africa. *Journal of Ethnopharmacology*, 135(3): 696-710.

Paper received for publication in September, 2019
Paper accepted for publication in November, 2019