Wetland Medicinal Plants of Eastern Himalayan Highlands of Gasa District, Bhutan

Sangay Tenzin* and Pema Tendar

*Department of Science, Chundu Armed Forces Public School, Ministry of Education, Haa, Bhutan.

Authors’ contribution

This work was carried out in collaboration between both authors. Author ST designed the study, wrote the protocol and wrote the first draft of the manuscript. Author PT performed the statistical analysis and literature searches. Both the authors read and approved the final manuscript.

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(1) Dr. Shiamala Devi Ramaiya, Universiti Putra Malaysia (UPM), Malaysia.
(2) A. B. M. Helal Uddin, International Islamic University Malaysia, Malaysia.
(2) Divya Jain, Banasthali Vidyapith, India.
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ABSTRACT

This paper documents the medicinal plant species in wetlands of the Eastern Himalayan Highlands of Gasa District, Bhutan. A random quadrat sampling method was used to assess the presence-absence of species. The study was conducted at Khatoed and Khamaed gewogs (blocks), Gasa District between January and December 2018. Identification of medicinal plant species and families were done in consultation with a botanist at the herbarium in Thimphu and volumes of Flora of Bhutan were referred. Based on the published and authentic scientific literature, information on medical uses of plant parts was collected. A total of 74 species of medicinal plant species in the wetlands, distributed in 69 genera and 43 families have been recorded. The study suggests preserving invaluable wetland medicinal plants and integrating ethno-medicinal practices in our lives.

Keywords: Wetlands; medicinal plants; diseases; Bhutan; Himalaya.

1. INTRODUCTION

Medicinal plants play a vital role in the lives of almost all people. About 65-80% of the world population uses ethno-medicine for their primary health cares [1]. World Health Organization [2] reported an increase in use of herbal remedies as increased number of governments and health
practitioners accepted and integrated ethno-botanical practices. In the world, plant-based companies like traditional medicine and aromatic cosmetic industries uses more than 13,000 plant species of which 8,000 species are used in South Asia alone [3,4]. From South Asian countries, India and China is reported to use 20% and 18.5% of their plants flora as medicinal plants respectively [5]. Muzzafar et al. [6] also confirmed that 85% of ethno-medicines used for primary health cares are from the plant derivatives.

Bhutan practiced traditional medicine similar to neighboring Tibet and Mongolia since 2500 years ago and known as the ‘men-jong’ the ‘Land of Medicinal Plant’ for possessing wealth of medicinal plant species [1,7]. This may be true because Bhutan has currently 70.46% of forest cover [8], which is greater than the constitutionally mandated 60% [9]. These abundant invaluable ethno-botanical and ethno-medicinal plants has provided main source of livelihood for rural and semi-urban people of Bhutan [8,10]. Bhutanese people in the past had used raw medicinal plants for ailment against many diseases due to high cost and inaccessible to conventional modern medicines. Plant species having medicinal, social and economical values were found mostly concentrated in wetland ecosystem [11,12]. In addition, wetland biodiversity is also known to provide mostly medicine, food and fodder [4] besides being critical habitat for animal and plant communities and serving as the bases of food chain [12,13].

In 1967, Bhutanese Government recognized traditional medicine as an alternative healthcare system by entrusting Pharmaceutical and Research Unit (PRU) under Institute of Traditional Medicine Service (ITMS) with manufacturing of traditional medicines in the country [7]. More than 5603 high altitude plant species are recorded in the pharmacopoeia of Bhutanese traditional medicine [5]. Currently, ITMS formulates 98 traditional herbal compounds using 267 species [7]. The medicinal plants in commercially viable amount were collected from 267 species [7]. The medicinal plants in ITMS formulates 98 traditional herbal compounds Bhutanese traditional medicine as an alternative healthcare system and the ecosystem of the nature.

In pursuit of protecting, promoting and promulgating Traditional Medicine and preserving rich wetland biodiversity, the current paper is undertaken with the following objectives: (a) to provide checklist of medicinal plants in wetlands, (b) categorize medicinal plant parts for different medical uses found in wetland vegetation in Bhutan.

2. MATERIALS AND METHODS

2.1 Study Area

Study was conducted in Khamaed and Khatoed gewogs of Gasa District. The study area is a part of Jigme Dorji National Park in Bhutan. The wetlands studied, mainly occurred in the slopes, bottomlands, edges of ericaceous shrub lands, in depressions, fallow lands, adjoining managed wetlands, along small streams, and forest fragments bordered by natural vegetation [13]. The elevation for the wetlands ranges from 1597 to 2538 m above sea level, that extends roughly 28 km between these two blocks. The area experiences the mean annual (2008-2017) rainfall and air temperature from 498-1824 mm and 5.16 – 15.63°C, respectively (National Center for Hydrology and Meteorology, 2018).

2.2 Data Collections and Plant Identifications

Prior to field survey, a research permit (Applicant ID: 18623722325AIECE2754986, dated 05/01/2018) was obtained from the Ugyen Wangchuk Institute for Conservation and Environment Research, MoAF, RGoB, Bhutan. Floristic inventory and collection of specimens were done from January to December 2018. A random quadrat sampling method was used to assess the presence-absence of species [16]. The plant species from each site were collected with nametag, date and brief description of their habitat. These collected plant specimens were taken to Herbarium, Thimphu, Bhutan for confirmation in consultation with experienced staff/Botanists. Flora of Bhutan [17,18,19,20, 21,22,23,24,25] was used for the identification of.
species and families. All the voucher specimens were deposited at the Herbarium, National Biodiversity Center, Thimphu, Bhutan.

The information on medicinal uses of plant parts (roots, rhizomes, stems, flowers, bulbs, barks, fruits, leaves, whole parts) were collected from published and authentic scientific literatures; journals, practical guidebooks, and thesis books [26]. The category of disease groups [27] and life form groups [7] were followed with slight modifications.

3. RESULTS AND DISCUSSION

3.1 Medicinal Plants and their Life form

A total of 74 species of medicinal plants in the wetlands, distributed in 69 genera and 43 families have been recorded. The three most dominant families represented for medicinal plants were Rosaceae, Ericaceae and Asteraceae, and Orchidaceae, having 7, 6, and 4 species, respectively (Table 1). This indicates that these species representation are from the wetland habitat as they are acid loving plants [16]. Similar study conducted in Eastern Bhutan also reported that the most represented medicinal plant families were Asteraceae and Rosaceae [8]. This presence of family dominance indicates that their collections of specimens may be from wetland areas. However, similar study conducted in Nepal and China recorded Asteraceae in the top three dominant families (Poaceae, Cyperaceae, Asteraceae) of wetland vegetation [11,4].

The herbaceous and shrub life form were the most abundant species represented with 58% and 30% while the trees and lianas were least represented at 7% and 5% of the total species (Fig. 2). An occurrence of higher proportion of shrubs and herbs is an indication of wetland vegetation [16]. Such distribution may be considered as the typical distribution in Himalayan temperate region [26] including lower montane areas [8]. This result is limited to present study and may not represent the actual status of life form of medicinal plants within wetlands in Bhutan. Every species recorded is provided with family name, life form, medicinal use and the part used (Table 1 and Fig. 3).

Fig. 1. Gasa, the location for study sites
Fig. 2. The proportion of life form occurred in wetland vegetation

Fig. 3. Representative medicinal plants in wetlands: (a) *Acorus calamus* L., (b) *Houttuynia cordata* Thunb., (c) *Colocasia esculenta* (L.) Schott, (d) *Spiranthes sinensis* (Pers.) Ames (e) *Dichroa febrifuga* lour., (f) *Rosa brunonii* Lindl. (g) *Holboellia latifolia* Wall., (h) *Berberis aristata* DC. (i) *Rubus paniculatus* Sm., (j) *Cannabis sativa* L., (k) *Enkianthus deflexus* (Griff.) C.K. Schneid., (l) *Rubus ellipticus* Sm
Table 1. List of medicinal plants occurred in wetland vegetation of Gasa, Bhutan

| Sl. No. | Scientific name                  | Family              | Life form | Part use          | Medicinal uses                                                                 |
|---------|----------------------------------|---------------------|-----------|-------------------|--------------------------------------------------------------------------------|
| 1       | Acorus calamus L.                | Acoraceae           | Herb      | Rhizome/shoot     | Used in fever, constipation, bronchitis, cough, diarrhea, dysentery, piles [28], asthma, digestive problems (gas, bloating, colic) [29], nervine, [30], eupeptic, allay indigestion [15], scabies, fracture, edema and gout [23] |
| 2       | Ageratina adenophora (Spreng.) R.M. King & H. Rob. | Asteraceae          | Shrub     | Leaf              | Used to cure cut and fever [31]                                                 |
| 3       | Ainsliaea latifolia (D. Don) Sch. Bip. | Asteraceae          | Herb      | Root              | Used in digestive problem i.e., colic [32]                                     |
| 4       | Alnus nepalensis D. Don Betulaceae | Tree                | Leaf/branch | Used in reducing swelling and preventing sweating [15]. |
| 5       | Anseraema flavum (Forssk.) Schott | Araceae             | Herb      | Bulb              | Used in chronic trachitis, bronchitis, tetanus, epilepsy, and skin diseases [32] |
| 6       | Artemisia indica Wild. Asteraceae | Herb                | leaf/young shoot | Used to treat fever, cut, scabies, anthelmintic [31], vomiting, dizziness, high blood pressure, headache and skin diseases [33] |
| 7       | Aster neoelegans Grierson Asteraceae | Herb                | whole plant/aerial parts | Used for reducing fever arising from poisoning and heals wounds, mumps and body swelling [7,34]. |
| 8       | Astilbe rivularis Buch.-Ham. ex D. Don Saxifragaceae | Herb                | leaf/root | Used for blood purification, toothache [32], tonic, diarrhea, dysentery [31], body ache, sprain and post-partum recovery [33] |
| 9       | Berberis aristata DC. Berberidaceae | Shrub              | root/bark | Used in eye diseases, diarrhea, jaundice, skin diseases, syphilis, chronic rheumatism, urinary disorders, diabetes, jaundice, gastrointestinal problem [29,35], malaria fever, in relieving pyrexia, as a wash for ulcer sores, as an eye lotion in conjunctivitis [36,37], allays chronic cough and cold [15,34]. |
| 10      | Cannabis sativa L.               | Cannabaceae         | Herb      | leaf/flower/seed  | Used in bronchitis, cuts, dyspepsia, skin disorders, cold, cough, epilepsy, sores [28], stomach disorders [15], diarrhea and head ache [31]. |
| 11      | Centella asiatica (L.) Urb. Apiceae | Herb                | whole plant/leaf/root | Used for mental peace, as a blood purifier, for skin diseases [37], to treat cuts [15], nervine tonic, anti-ulcerative [30], heat sickness, to improve memory and diuretic [31]. |
| 12      | Cirsium falconeri (Hook. fil.) Petr. Asteraceae | Herb                | -         | Used as medicinal plant [15]                                                  |
| 13      | Coelogyne stricta (D. Don) Schltr. Orchidaceae | Herb                | Pseudobulb | Used for headache and fever [38].                                             |
| 14      | Colocasia esculenta (L.) Schott Araceae | Herb                | leaf/rhizome | Used for fever and cough [15,39].                                             |
| 15      | Commelina diffusa Burm. f. Commelinaceae | Herb                | stem /leaf | Treatment of abscess, boils, malaria, for treatment of insect, snake and bug bites, edema, laryngitis, sore throats, acute tonsillitis, otitis media, in nose bleeding [40], boils, burns, and itches [11,39]. |
| 16      | Commelina paludosa Blume Commelinaceae | Herb                | whole plant | Used in treatment of sexual impotency [29].                                  |
| 17      | Crassocephalum crepidoïdes (Benth.) S. Moore Asteraceae | Herb                | whole plant | Stops wound bleeding and cure headache [15].                                  |
| 18      | Cymbidium iridioides D. Don Orchidaceae | Herb                | Leaf       | Used in blood clotting in deep wounds [38].                                 |
| Sl. No. | Scientific name          | Family       | Life form | Part use              | Medicinal uses                                                                 |
|--------|--------------------------|--------------|-----------|-----------------------|--------------------------------------------------------------------------------|
| 19     | Cynoglossum lanceolatum Forssk. | Boraginaceae | Herb      | Aerial parts/leaf/stem | Used in cold sores, afts, headache [41] and chest [42].                         |
| 20     | Daphne bholua Buch.-Ham. ex D. Don | Thymelaeaceae | Shrub     | bark/root/stem        | To treat fever [15] and to expel intestinal worms [43].                        |
| 21     | Dendrobium fimbriatum Hook. | Orchidaceae  | Herb      | Whole plant           | Used in liver upsets and nervous debility [38].                               |
| 22     | Dichroa febrifuga lour. | Hydrangeaceae | Shrub     | shoot/root            | To prepare a febrifuge (anti-fever) [19,15], and to cure fever [31].          |
| 23     | Dipacus inermis Wall. | Caprifoliaceae | Herb     | Root/leaf             | Used as medicine [6].                                                         |
| 24     | Drynaria propinqua (Wall. ex Mett.) Bedd | Polypodiaceae | Herb     | stem/rhizome          | Used in fracture [31], antidote, detoxifier, and poisoning [44,15].            |
| 25     | Dryopteris juxtaporosa Christ | Dryopteridaceae | Herb    | leaf                  | Used to cure chest and intestinal problems [42].                              |
| 26     | Elsholtzia fruticosa (D. Don) Rehder | Lamiaceae    | Shrub     | leaf/seed             | To treat headache and anodyne [32].                                           |
| 27     | Enkianthus deflexus (Griff.) C.K. Schneid. | Ericaceae  | Shrub     | Twig                  | To relieve gastric and indigestion problems [45].                             |
| 28     | Erythrina arborescens   | Fabaceae     | Tree      | Seed/bark             | Used to treat dysentery [31], febrifuge for kidney disorders, urine infection, back pain, giddiness, and disabilities [44]. |
| 29     | Fragaria rubicola (Hook. f.) Lindl. ex Lacaita | Rosaceae | Herb      | Whole plant/fruit     | Anthelmintic and heals neurological and chest infections, and lung inflammation [34,6] |
| 30     | Gaulium aparine L.      | Rubiaceae    | Herb      | whole plant/aerial parts | Used for migraine, sinusitis, jaundice [1], aperients and diuretic [46].    |
| 31     | Gaultheria nummularioides D. Don | Ericaceae   | Shrub     | leaf/fruit            | Antiseptic, carminative and neural stimulant [32].                           |
| 32     | Geranium procurrens Yeo | Geraniaceae  | Herb      | Root                  | Useful for cough and cold, bronchitis, the swelling of limbs, anti diarrheal, antitoxic and antimalarial [34]. |
| 33     | Girardinia diversifolia (Link) Friis | Urticaceae | Herb      | leaf/twig/bark        | Used to treat gonorrhea [32,15], diabetes, fibre and fracture [31].          |
| 34     | Halenia elliptica D. Don | Gentianaceae | Herb      | Aerial parts          | Heals wounds, allays common cough & cold, and headaches caused by the disturbances in blood and bile [7]. |
| 35     | Hedera nepalensis K. Koch | Araliaceae  | Liana     | whole plant           | Stimulant, diaphoretic, cathartic, rheumatism and emmenogouge [32]          |
| 36     | Holboellia latifolia Wall. | Lardizabalaceae | Liana   | fruit                 | Used for treating rheumatism [15].                                           |
| 37     | Houttuynia cordata Thunb. | Saururaceae  | Herb      | Whole plant/root      | Used against dysentery/diarrhea [15], indigestion and skin diseases [31].   |
| 38     | Hydrocotyle sibbithorpioides Lam. | Araliaceae | Herb      | leaf                  | Used against dysentery, diarrhea, piles, rheumatism, digestive [29], and treating urinary problems [11]. |
| 39     | Impatiens arguta Hook. f. & Thomson | Balsaminaceae | Herb     | Leaf                  | Used to treat old wounds [43].                                               |
| 40     | Impatiens racemosa DC | Balsaminaceae | Herb     | Seed/fruit            | Used to cure cold and cough [32].                                             |
| 41     | Jasminum humile L.      | Oleaceae     | Shrub     | Leaf/bark/fruit       | Used in wounds [31], sinus and skin disorders [32].                          |
| Sl. No. | Scientific name                          | Family         | Life form | Part use          | Medicinal uses                                                                                                                                 |
|--------|-----------------------------------------|----------------|-----------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 42     | *Juglans regia* L.                      | Juglandaceae   | Tree      | whole plant/nut/bark/b ranch | Used for cleaning of teeth, applied on teeth during pain, valuable for enhancing the memory [36], used against diabetes [47], anthelmintic [31], heals air disorders such as headache, nausea, blurred vision [15] |
| 43     | *Ligustrum confusum* Decne.             | Oleaceae       | Shrub     | leaf              | Used as diuretic [21].                                                                                                                            |
| 44     | *Lyonia ovalifolia* (Wall.) Drude       | Ericaceae      | Shrub     | stem/leaf         | Used to treat boils, pimples, skin eruptions, worms, wounds [32], and scabies [31].                                                           |
| 45     | *Mahonia nepalensis* DC.                | Berberidaceae  | Shrub     | stem/wood         | Used for the treatment of skin diseases like eczema and psoriasis [48]                                                                         |
| 46     | *Nasturtium officinale* W.T. Aiton      | Brassicaceae   | Herb      | Leaf/whole plant  | Used for the treatment of allergic problems and as diuretic, tonic to recover health and strength [49], constipation, goiter and vermifuge [32]. |
| 47     | *Oenanthe javanica* (Blume) DC.         | Apiaceae       | Herb      | Leaf/whole parts  | Used in anti-diabetic, anti-arrhythmic, anti-inflammatory, neuroprotective, alcohol detoxification, anti-toxic, anti-coagulant, hepatoprotective, anti-HBV and memory improvement [50] |
| 48     | *Parochetus communis* Buch.-Ham. ex D. Don | Fabaceae    | Herb      | leaf              | Used for stomach disease of babies, and earache [32].                                                                                           |
| 49     | *Persicaria nepalensis* (Meisn.) H. Gross | Polygonaceae | Herb      | whole plant       | Used against swelling in the body parts [32].                                                                                                   |
| 50     | *Pieris formosa* (Wall.) D. Don          | Ericaceae      | Shrub     | Leaf/twig         | Used to treat irritating skin diseases, however, extract of leaves & twigs are highly poisonous to people and local animals [43].                     |
| 51     | *Plantago eosa* Wall.                   | Plantaginaceae | Herb      | seed/root/leaf    | Used against diarrhea [51], bone fracture, and inflammation [32]                                                                               |
| 52     | *Potamogeton crispus* L.                | Potamogetonaceae | Herb   | whole plant       | Used as diuretic and treatment of urinary tract infections [50].                                                                               |
| 53     | *Primula denticulata* Sm.               | Primulaceae    | Herb      | Flower/leaf       | Used to treat diabetes, urinary ailments [32] and eye infections [42].                                                                        |
| 54     | *Prinsepia utilis* Royle                | Rosaceae       | Shrub     | fruit/root        | Used against burns, cuts and rheumatic [32]                                                                                                   |
| 55     | *Prunella vulgaris* L.                  | Lamiaceae      | Herb      | whole plant       | To treat breath problems, lung complaints, liver & cerebral complaints, cold, fever, gastric complaints and headache [32,6].                     |
| 56     | *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae | Tree       | Nut               | Used against diarrhea [15]                                                                                                                     |
| 57     | *Ranunculus fluitus* DC                 | Ranunculaceae  | Herb      | whole plant/leaf  | Used to treat skin infection [52] and boils [32].                                                                                            |
| 58     | *Rhododendron arboreum* Sm.             | Ericaceae      | Shrub     | Flower/leaf       | Used to treat mental retardation, dysentery, headache, eye cataract, wounds, rheumatism [53,31,32], diarrhea [15], and heart problems [36]. |
| 59     | *Rosa brunonii* Lindl.                  | Rosaceae       | Shrub     | Root              | Used to relief pain [32].                                                                                                                       |
| 60     | *Rosa sericea* Lindl.                   | Rosaceae       | Shrub     | flower            | Useful for bile and air related disorders [7,19].                                                                                             |
| Sl. No. | Scientific name                  | Family          | Life form | Part use          | Medicinal uses                                                                                                                                 |
|--------|---------------------------------|-----------------|-----------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 61     | Rubus biflorus Buch.-Ham. ex Sm.| Rosaceae        | Shrub     | stem without bark | Useful for reducing blood pressure, common cold, and pleural effusion [7].                                                                 |
| 62     | Rubus ellipticus Sm.             | Rosaceae        | Liana     | fruit/shoot/root/ bark | Used in treatment of fevers, diarrhea [48], gastric troubles, dysentery, colic, coughs [15], sore throat, skin diseases, wounds, tumors, cholera [36], jaundice, typhoid [31] and has antioxidant properties [29]. |
| 63     | Rubus paniculatus Sm.            | Rosaceae        | Liana     | fruit             | Used against diarrhea and stomach disorders [32].                                                                                          |
| 64     | Rumex nepalensis Spreng.         | Polygonaceae    | Herb      | leaf/root/twig    | Used in treatment of colic, headache [47], skin diseases, wound healing and anti-allergic properties [29], against hair loss [15], boils, diuretic, purgative, scurvy and swelling of muscle [32]. |
| 65     | Scurrula elata (Edgew.) Danser   | Loranthaceae    | Shrub     | leaf              | Reduce galls [31].                                                                                                                           |
| 66     | Spiranthes sinensis (Pers.) Ames | Orchidaceae     | Herb      | Root/stem         | Used in curing sores [38].                                                                                                                  |
| 67     | Strobilanthes auriculata Nees    | Acanthaceae     | Shrub     | Inflorescence     | To increase stamina and immunity against diseases [54].                                                                                      |
| 68     | Swertia bimaculata (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke | Gentianaceae    | Herb      | Leaf              | Used for the treatment of stomach disorders [43].                                                                                           |
| 69     | Taxus baccata L.                 | Taxaceae        | Tree      | leaf/bark/axil    | Used against asthma, bronchitis, lumbago, indigestion, cancer [53], cough [36], swelling, contraceptive [32] and as medicine [17].           |
| 70     | Thalictrum foliolosum DC.        | Ranunculaceae   | Herb      | Root              | Used to treat abdominal pain, blood purification, boils, earache, eczema, eye diseases, fever, leucoderma, piles, rheumatism, gout, tonic and toothache [32,18]. |
| 71     | Trifolium repens L.              | Fabaceae        | Herb      | whole plant       | Used against dandruff [32].                                                                                                                  |
| 72     | Vaccinium dunalianum Wight       | Ericaceae       | shrub     | Leaf              | Used to treat intestinal worms [43].                                                                                                         |
| 73     | Viburnum mullaha Buch.-Ham. ex D. Don | Adoxaceae    | Shrub     | leaf/fruit        | Used to treat stomachache and stimulant [32]                                                                                               |
| 74     | Zanthoxylum acahanpodiunum DC.   | Rutaceae        | shrub     | Leaf/fruit/twig   | Used externally to relieve abdominal pain and to relieve indigestion problems [45].                                                            |
Table 2. Category of diseases that could be treated by medicinal plants in wetlands of Gasa, Bhutan

| Sl.no. | Category of disease   | Common diseases/problems                                                                 | No. of species counted | % of species counted |
|--------|-----------------------|-----------------------------------------------------------------------------------------|------------------------|----------------------|
| 1      | Digestive diseases    | Dysentery, constipation, colic, tetanus, dyspepsia, aperients, vermifuge, diarrhea, anthelmintic and eupeptic | 47                     | 20.2                 |
| 2      | Skin diseases         | Scabies, boils, wounds, cut, abscess and sore                                             | 35                     | 15.0                 |
| 3      | Respiratory diseases  | Bronchitis, lungs problem, cough and cold, throat problem and tracheitis                  | 24                     | 10.3                 |
| 4      | Weather sickness      | Fever, headache, sickness, flu, malaria, anodyne and migraine                            | 23                     | 9.9                  |
| 5      | Neurological diseases | Nervine, epilepsy, dizziness and stimulants                                               | 17                     | 7.3                  |
| 6      | Tonic                 | Kidney, liver, heart, blood, health, oedema, blood clotting and sinus                      | 16                     | 6.9                  |
| 7      | Kidney diseases       | Diabetes, diuretic and urinary disorders                                                  | 16                     | 6.9                  |
| 8      | Ear, nose and ear (ENT) diseases | Red eye/conjunctivitis, nose bleeds, jaundice and otitis                           | 13                     | 5.6                  |
| 9      | Osteoarthritis diseases | Joint pains, arthritis, fracture, mumps, sprains and rheumatism                           | 13                     | 5.6                  |
| 10     | Detoxification        | Food allergy, insect allergy, poisoning and antidote                                      | 9                      | 3.9                  |
| 11     | Stomach diseases      | Stomach pain, ulcers, colonic problems                                                   | 8                      | 3.4                  |
| 12     | Hot diseases in body  | Heat sickness, burns, inflammation and diaphoretic                                         | 6                      | 2.5                  |
| 13     | Disease of mouth      | Tooth decay and halitosis                                                                 | 3                      | 1.2                  |
| 14     | Blood pressure diseases | High and low blood pressure                                                               | 2                      | 0.9                  |
| 15     | Disease caused by animal bites | Snake and insect bites                                                                    | 1                      | 0.4                  |
3.2 Medicinal Plants and their Usage

Almost every part of plants (leaf, bark, stem, shoot, flower, etc.) or sometime whole part is collected for the medicinal purposes. The three most plant parts used for medicine were leaf (47%), whole plant (23%) and root (22%) (Fig. 4), and this representation may differ on part usages [8]. The locally prepared drugs were regularly used and proven to be effective, cheap and beneficial with almost no side effect compared to the allopathic drugs [42]. The local population use indigenous knowledge to cure various diseases [42] and keep the practices intact through personal experiences and ancestral prescription [8]. Given the current trend of modernization, much of this knowledge is disappearing along with the traditional lifestyle and retreats of wetland [4]. Therefore, study of traditional knowledge on wetland medicinal plants is needed, while such knowledge still exists. This would enable the traditional medicine to complements the modern medicines adequately.

These wetland medicinal plant species were found effective against 15 categories of diseases (Table 2). Common diseases such as digestion (20.2%), skin (15%), respiratory (10.3%) and weather sicknesses (9.9%), were mostly treated which may be caused due to unhygienic practices at home. The use of medicinal plants against snake and insect bites were least (0.4%) represented, which may be due to collection difficulties or not able to identify these plants (Table 2). Uses of these medicinal plants against diseases varied from region to region. For instance, people of Rampur Ghol, Nepal use Centella asiatica (L.) Urb. for fever, diarrhea, and dysentery [11], while people of Kilikhar, Mongar, eastern Bhutan use it for hypertension and improving memory power [8]. The difference in the way medicinal plants are used for curing different diseases may be due to the local ethnobotanical practices and the prevalence of endemics diseases in the specific localities.

Species such as Acorus calamus L. is found richly in shallow fresh marsh of Bhutan [13]. However, it is vulnerable in Himachal Pradesh [54,55,26]. Similarly, the Thalictrum foliolosum DC species occurred in wetlands of Bhutan but is considered endangered in Himachal Pradesh, India [55]. The reasons may be due to lack of awareness of its uses by Bhutanese people and over harvesting in India, respectively. The root, rhizome, bark and shoot of these species were found to be effective against many diseases (Table 2). This may encourage illegal, unsustainable and irrational non-scientific harvesting method like uprooting whole plant and potentially causing extinction. To preserve such invaluable wetland medicinal plants and integrate ethno-medicinal practices in our lives, sensitization on the uses of medicinal plants in their locality is recommended.

4. CONCLUSION

The wetland plants provide different ailments against different categories of diseases. Uses of medicinal plant parts differed according to the local communities and prevalence of endemic diseases. Families of medicinal plants such as Rosaceae, Ericaceae and Asteraceae were found dominant in the wetlands. In-depth study is recommended to explore other potentially important plants species in the wetlands in Bhutan. Our data may be useful for science education program in school or for species-level conservation measures by concerned agencies. Additionally, it may be useful for carrying out bioprospecting and phytochemical studies in future to formulate more traditional herbal remedies by ITMS and to add on to the list of the pharmacopoeia of Bhutanese traditional medicine. Thus, it is imperative for local communities, herbalist, park services and ITMS to collaborate for better planning and management of the wetland vegetation in Bhutan.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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