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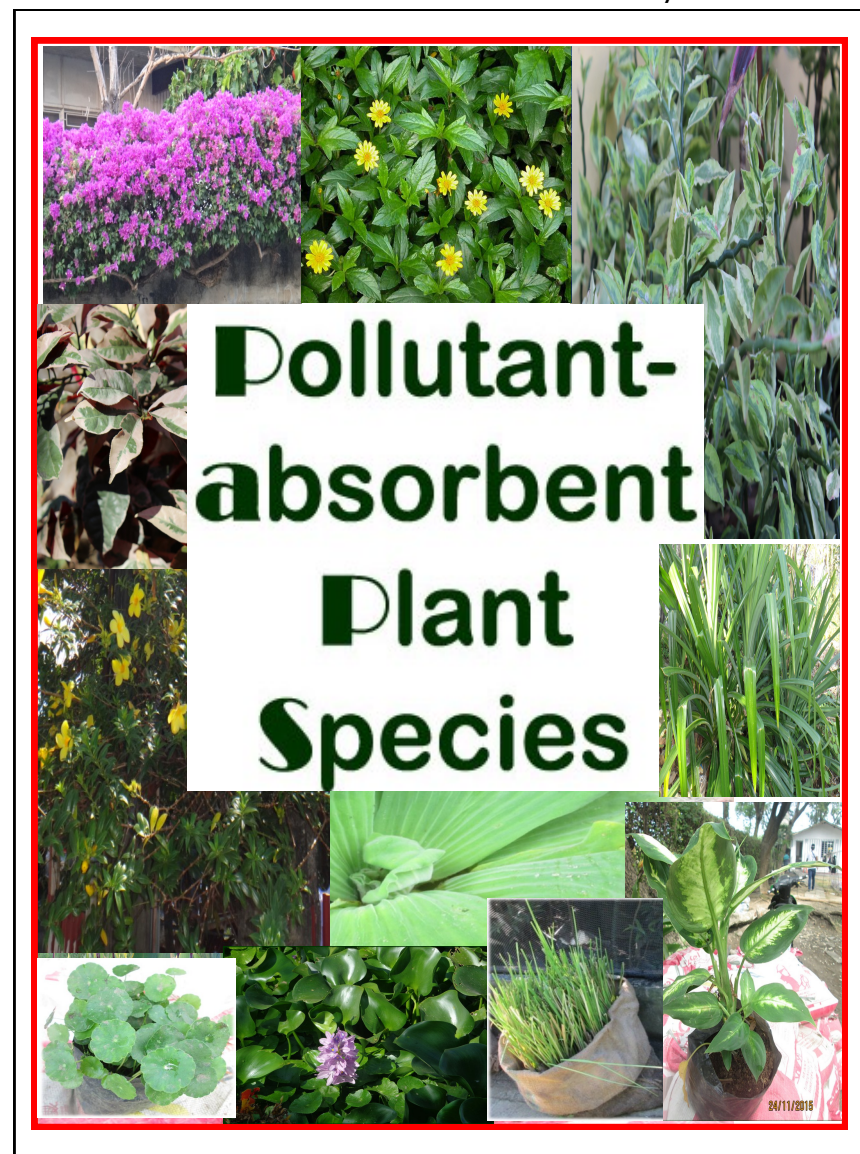
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Foreword

Air pollution is considered as a major problem in the National Capital Region. Increase in number of vehicles and industries are considered its major contributors in the metropolis. Smog hanging over cities is the most familiar form of air pollution. In addition, particulate matters and nitrogen dioxide found in the atmosphere are found to be hazardous to human health.

As such, a key strategy identified to address this problem is to plant more trees within the metropolis. Relatively, DENR-ERDB has conducted research studies to identify the kinds of plants that can absorb air pollutants. These plants can tolerate and collect chemicals that are harmful to human health and help decrease pollutants in the atmosphere, both outdoors and indoors. Henceforth, these plants are useful to improve urban air quality.

This booklet is prepared to provide information regarding various pollutant-absorbent plant species that can be planted in an urban area through vertical garden as well as in a floating garden. Moreover, plants capable to absorb pollutants in polluted waterways are highlighted in this booklet.

NERY A. ALBA
Center Head, THWRDEC

Introduction

Air pollution is one of the major environmental problems in Metro Manila. One of the simplest and easiest way to lessen-if not totally eliminate-the amount of toxic gases in the air is to plant pollutant-absorbent plant species. A series of laboratory and field test of plant species to determine degrees of resistance to pollution revealed the list of plant species considered as highly resistant to pollution. Moreover, said plant species were found to be efficient absorbers of toxic gases like sulfur dioxide (SO₂) and nitrogen dioxide (NO₂), thus addressing the issue on climate change. In order to address the city's limited space it is recommended that these pollutant-absorbent plant species be planted vertically.

The list of pollutant-absorbent plant species for urban greening were provided in a previous study undertaken by then ERDS-NCR in 1992. In terms of environmental benefits, the use of recommended pollutant-absorbent plant species in greening activities can help absorb heated gas in the air, lower both indoor and outdoor temperature, thus, providing a healthier indoor air quality. Moreover, these identified pollutant-absorbent plant species are highly recommended for vertical/urban greening in the metropolis.

The booklet is packaged to provide information on the different pollutant-absorbent plant species, their description, distribution, propagation, cultivation and benefits.

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Distribution:

- Water lettuce is present in the states of the southeast U.S. and north to New Jersey and New York, and westward to Texas, Arizona and California. Also present in Hawaii, Puerto Rico and the Virgin Islands.

Propagation:

- Although sexual reproduction is exceedingly rare in the home aquarium, the flowers are tiny and are located at the center of the plant. Each plant will only have either male or female flowers. If successful fertilization occurs, a small, many-seeded green berry will form. Asexual reproduction is far more common in the home aquarium, and smaller daughter plants will form floating beside their mother plant, connected by a short stolon.

Cultivation:

- Water lettuce cultivates in nearly all tropical and subtropical freshwater areas and is considered an invasive species and a mosquito breeding habitat.

Benefit/Use:

- Water lettuce can absorb zinc at an average of 41.1200 mg/kg.¹

¹ Engr. Teresa Salanguit. 2017. Phytoremediation schemes for polluted waterways in urban areas. ERDB-THWRDEC, Quezon City

Bougainvillea

Scientific name: *Bougainvillea spectabilis* Willd.

Common name: Bogambilya

Family name: Nyctaginaceae



Description:

- It grows as a shrub or thorny, woody vine reaching upwards of 12 meters tall and 7 meters wide;
- Leaves are simple and alternate, oval in shape, tapering to a point. Leaf size ranges from 4-13 centimeters long and 2-6 centimeters wide;
- The hermaphroditic flowers are small, tubular and white, typically in clusters of three, surrounded by three papery bracts vary in color from magenta and purple to orange, white and yellow.

Distribution:

- *Bougainvillea spectabilis* is native to Brazil, Peru, Bolivia, and Chubut Province, Argentina, but it has been introduced in many other areas.

Propagation:

- Bougainvillea is propagated from tip cuttings.

Cultivation:

- It thrive in almost any kind of soil as long as it is well-drained. They are sun-loving plants, drought and salt tolerant plant species. Requires little care once established, except for pruning to control wayward growth.

Benefits/Uses:

- Bougainvillea is one of the identified pollutant-absorbent plant species. It can absorb *nitrogen dioxide* chemicals present in the air we breathe.¹
- The antibacterial action of various extracts of *Bougainvillea spectabilis* leaves may indicate their potential as antibacterial herbal remedies. Its leaves have high potential of antimicrobial activity.²

¹ Clementine Esguerra et al. 1982. Study on the Uptake of Sulfur Dioxide and Nitrogen Dioxide. UP Diliman, Quezon City

² Menakshi Bhatet et. al. 2009. Antidiabetic Properties of Azadiracta indica and Bougainvillea spectabilis: In Vivo Studies in Murine Diabetes Model, Institute of Bioinformatics and Biotechnology, India. , Department of Zoology, University of Pune, Pune, India.

Water Lettuce

Scientific name: *Pistia stratiotes* L.

Common name: Water cabbage, Kiapo

Family name: Araceae



Description:

- Water lettuce is often called water cabbage, water lettuce, Nile cabbage, or shellflower.
- It is a free-floating plant with many spongy, dusty green simple leaves.
- The leaves are covered in very fine hairs and are arranged in a spiral pattern from the center of the plant. The leaves are 1 to 6 inches wide and have large veins running their length.
- The flowers are seldom seen.
- Water lettuce is a very aggressive invader and it can form thick floating mats.

Distribution:

- Vetiver plant is native to Andaman Is., Borneo, Cambodia, Jawa, Laos, Lesser Sunda Is., Myanmar, Philippines, Sumatera, Thailand, Vietnam.

Propagation:

Vetiver can be propagated in four common ways, namely:

- Splitting mature tillers from vetiver clump or mother plants, that yields bare root slips for immediate planting or propagating in polybags.
- Using various parts of a mother vetiver plant.
- Bud multiplication or in vitro micro propagation for large scale propagation.
- Tissue culture, using a small part of the plant to propagate on a large scale.

Cultivation:

- The vetiver plant is highly drought-tolerant and can help to protect soil against sheet erosion. In case of sediment deposition, new roots can grow out of buried nodes.

Benefit/Use:

- Vetiver Grass can absorb zinc at an average of 52.0433mg/kg.¹

¹ Engr. Teresa Salanguit. 2017. Phytoremediation schemes for polluted waterways in urban areas. ERDB-THWRDEC. Quezon City

Creeping Daisy

Scientific name: *Sphagneticola trilobata* (L.) Pruski

Common names: Trailing Daisy, Singapore Daisy

Family name: Asteraceae



Description:

- Plants are creeping and mat-forming, and the stems take root at the nodes. Solitary flower heads are 1 inch (2.5 cm) across and have yellow, three-notched rays and yellow disks.
- The rays are either solid yellow in color or tipped with paler yellow color.
- Leaves are fleshy, green, very shiny, serrate, and narrowly egg-shaped. Some of the leaves are tri-lobed with a pair of smaller side lobes.

Distribution:

- It is widespread as an invasive species on the Pacific Islands, Hong Kong, South Africa, Australia, Indonesia, and Sri Lanka.

Propagation:

- Seeds can be sown directly outside and should be kept moist until germination occurs.

Cultivation:

- Creeping daisy can be an excellent ground cover particularly to open grassland area to avoid too much exposure to sunlight particularly during dry season.

Benefits/Uses:

- *Wedelia trilobata* is used as traditional medicine. Its leaves and stems can be extracted and used as it has a strong antioxidants, antimicrobial and anti-inflammatory properties.¹
- As it is an excellent ground cover, it is highly recommended to be planted in a polluted environment to absorb heavy metals, specifically sulfur dioxide, that are harmful to human health.²

¹ Govindappa M. et al. 2011. Antimicrobial, antioxidant and in vitro anti-inflammatory activity of ethanol extract and active phytochemical screening of *Wedelia trilobata*. Journal of Pharmacognosy and Phytotherapy. Vol. 3(3). 43-51.

² Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide.

Vetiver Grass

Scientific name: *Chrysopogon zizaniodes* L. Roberty

Common name: Moras

Family name: Poaceae



Description:

- Vetiver grows up to 150 centimetres (5 ft) high and forms clumps. Under favorable conditions, the erect culms can reach 3 meters in height.
- The stems are tall and its leaves are long, thin, and are rather rigid.
- The flowers are brownish-purple in color. Its roots grow downward, 2 meters (7 ft) to 4 meters (13 ft) in depth.
- The plant stems are erect and stiff. They can survive deep water flow. In clear waters, the plant can survive up to two months.

*D*istribution:

- native to the tropical Americas —from Southern Mexico, through Central America, to northern South America and Brazil. Also, it is native to several Caribbean islands, including Puerto Rico.

*P*ropagation:

- The easiest way to propagate marian is by rooting its cuttings using either tip cuttings or stem cuttings. Plant these small pieces of greenery in the right medium and they will produce roots and, eventually, an entirely new plant.

*C*ultivation:

- It is usually grown as a potted plant for its handsome foliage.

*B*enefit/Use:

- Marian can absorb zinc at an average of 48.0150mg/kg.¹

¹ Engr. Teresa Salangit. 2017. Phytoremediation schemes for polluted waterways in urban areas. ERDB-THWRDEC. Quezon City.

Madagascar Periwinkle

Scientific name: *Catharanthus roseus* (L.) G. Don

Common name: Tsitsirika, Atay-bia

Family name: Apocynaceae



*D*escription:

- Locally known as tsitsirika.
- A fleshy perennial that can grow up to 32 inches (80 cm) high.
- It is also an erect, smooth or slightly hairy, simple or slightly branched plant.
- Its stems are somewhat woody.
- The leaves are oblong-shaped, 4 to 7 centimeters long, rounded at the tip, and pointed at base.
- Flowers are white, pink, red, or variegated white and red colors, 3.5 centimeters to 5 centimeters across and borne in the axils of the leaves.

Distribution:

- It grows in Australia and listed as a noxious weed in Western Australia and the Australian Capital Territory, and also in parts of eastern Queensland.

Propagation:

- Undisturbed propagation of the original species is through seeds. Newer cultivars which produce sterile seeds are propagated by stem cuttings dipped in rooting hormones in controlled environments such as greenhouses.

Cultivation:

- A hardy ornamental known to withstand dry and nutritionally deficient soils. A sun-loving ornamental, it is suitable for urban/vertical planting, and it can be planted in small pots and in limited areas.

Benefits/Uses:

- **Tsitsirika** (periwinkle) has an active ingredient called vinealeukoblastine known to prevent leukemia (cancer of the blood). Its leaf extract is known to be an anticancer product.¹
- It can be planted in a vertical garden as it is good in absorbing nitrogen dioxide in an urban setting.²

¹ Mendioro, M.S. et al. 2001. Cytogenetic effects of medicinal plants for diabetes mellitus on human leukocytes culture *in vitro*. The Philippine Agricultural Scientist. vol. 64. no.1:58-64.

² Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide. UP Diliman,

Diffenbachia

Scientific name: ***Dieffenbachia seguine*** (Jacq.) Schott

Common name: Marian, Dumb cane

Family name: Araceae



Description:

- A perennial herbaceous plant with straight stem, simple and alternate leaves containing white spots and flecks, making it attractive as indoor foliage. Species in this genus are popular as houseplants because of their tolerance of shade.
- It has a unique type of flower; a spathe and spadix make up the inflorescence (imperfect bloom). The flowers are insect-pollinated. It seldom flowers indoors, and the blooms are not showy.
- Its fruit appears berry-like when it develops.

Distribution:

- Water hyacinth originated from Amazonia and spread naturally throughout South America.

Propagation:

Scoop a mature water hyacinth plant out of the water. Then, place the plant on a work surface protected with several layers of newspaper and examine the base of the plant. Look for the smaller daughter plants attached to the parent plant by thin side shoots, or stolons. Cut the stolons, then remove several of the young plants from the parent. Keep the parent plant for faster establishment, or simply grow the daughter plants. Lastly, place the detached plants in a bucket of water, then transfer them as soon as possible, to the surface of a closed pond where it will receive at least partial sunlight.

Cultivation:

- Water hyacinth thrives in a wide range of freshwater habitats (shallow ponds, marshes, small streams, lakes and rivers) provided they are not saline or do not become salty during drought.

Benefit/Use:

- Water hyacinth can absorb zinc at an average of 52.0433 mg/kg.¹

¹ Engr. Teresa Salangit, 2017. Phytoremediation schemes for polluted waterways in urban areas. ERDB-THWRDEC. Quezon City.

Yellow Bell

Scientific name: *Allamanda cathartica* L.

Common Name: Kampanilya, Golden trumpet

Family name: Apocynaceae



Description:

- It is a vigorous, smooth, slightly hairy shrub growing 2 to 4 meters high.
- Leaves are opposite and in whorls of 3 or 4, although the upper ones may be scattered, lanceolate or oblong-lanceolate, 8 to 12 centimeters long, 2.5 to 4 centimeters wide, pointed on both ends.
- Flowers are yellow and short-stalked.

Distribution:

- *Allamanda cathartica* is native to Brazil and widely distributed in tropical areas.

Propagation:

- Yellow bell can be propagated from hardwood and softwood cuttings

Cultivation:

- Yellow bell grows well in sunny areas with adequate rainfall and perpetually moist substrates. However it does not tolerate shade and salty or alkaline soils.
- Prune the plant to use it as a shrub. Train it up on trails or on the side of a building where there is

Benefits/Uses:

- The leaf extract of *Allamanda cathartica* possesses better wound healing activity and it can be used to treat different types of wounds.¹
- The seed extracts can be a good source of biodiesel.²
- Planting yellow bell within the metropolis can help in absorbing sulfur dioxide.³

¹ Shivananda Nayak et. Al. 2006. Evaluation of wound healing activity of *Allamanda cathartica*. L. and *Laurus nobilis*. L. extracts on rats. *BMC Complementary and Alternative Medicine*, The official journal of the International Society for Complementary Medicine Research (ISCMR)20066:12

² Evans C. Egwim et al. 2015. Production and characterization of biodiesel from *Allamanda cathartica* oil using lipase as catalyst, *Biokemistri*, An International Journal of the Nigerian Society for Experimental Biology, Vol. 27 (no. 4) 153–158, 31

³ Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide, *UP Diliman*

Water Hyacinth

Scientific name: *Eichhornia crassipes* (Mart.) Solms-Laub

Common name: Common water-hyacinth,
floating water hyacinth

Family name: Pontederiaceae



Description:

- Water hyacinth is a free floating perennial herb in freshwater ecosystems.
- It is found at the surface of rivers, lakes, canals and ponds and may root in the mud of shallow waters.
- Generally 10-20 centimeters high but can reach 1 meter high when established in dense mats.
- The leaves arise from the rhizome nodes and stand above the water. They are dark green in color, ovate and cordate at the base, borne on swollen bladder-like petioles.

- It consists of rhizomes, growing vertically down. They are creamish in color and covered with root hairs.
- The flowers are white or pinkish to red in color and are borne in small, rounded bunches (umbels) near the surface of the soil.

Distribution:

- It is native to the Pacific Basin, and has been introduced to Hawaii, Oregon and Florida.

Propagation:

- Pennywort reproduces through its seeds and its far-reaching runners, which root at the nodes and can survive after being separated from the parent plant.

Cultivation:

- It grows in temperate and tropical swampy areas in various regions around the world.

Benefit/Use:

- Pennywort can absorb zinc at an average of 25.6950mg/kg.¹

¹ Engr. Teresa Salangit. Phytoremediation schemes for polluted waterways in urban areas. 2017. ERDB-THWRDEC, Quezon City.

Chinese Croton

Scientific name: *Excoecaria cochinchinensis* Lour.

Common name: Picarra, Firestorm

Family name: Euphorbiaceae



Description:

- It is also called picarra in the Philippines.
- It is a low-growing shrub up to 1 meter with arching stems.
- Leaves are variegated pale green and off-white colors on top and bright lacquer red underneath.
- It prefers open, sunny places and rich soil and requires constant watering.

Distribution:

- A native plant in Southeast Asia and China.

Propagation:

- It can be propagated through softwood cuttings, semi-hardwood cuttings, and layering.

Cultivation:

- It needs partial to light shade. It also requires regular watering but should not be overwatered.

Benefits/Uses:

- When planted in walls the picarra plant can provide cooling capacity because of its lower surface and indoor temperatures than the reference wall up to 7.2°C and 3.3°C during the daytime in the summer respectively. The ability to reduce temperature and store carbon are also provided by these plants.¹
- It can absorb sulfur dioxide in a polluted environment.²

¹ Sasima Charoenkit et.al. 2011. Role of specific plant characteristics on thermal and carbon sequestration properties of living walls in tropical climate. Faculty of Architecture, Naresuan University, Phitsanulok, Thailand, Elsevier, Building and Environment, Vol. 115.

² Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide, UP Diliman.

Pennywort

Scientific name: ***Centella asiatica* (L.) Urb.**

Common name: : Takip kuhol

Family name: Apiaceae



Description:

- A succulent, perennial flowering plant
- The stems are slender, creeping stolons, green to reddish-green in color, connecting plants to each other.
- The leaves are borne on pericladial petioles, around 2 centimeters (0.79 in).

Distribution:

- *Canna indica* is distributed in eastern and south-eastern Australia, New Zealand, southern USA, southern and eastern Africa, Hawaii and several other Pacific islands.

Propagation:

- Bandera Espanola grows either from seeds or by planting rhizomes and thrive in sunny and humid locations. They can also adapt to different environmental conditions.

Cultivation:

- It grows in any type of soil. It needs at least six hours of exposure to sun in order to grow.

Benefits/Uses:

- Bandera Española - when placed in polluted waterways - can absorb zinc at an average of 33.5788 mg/kg.¹ Moreover, it can absorb nitrogen dioxide present in polluted air.²

¹ Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide. UP Diliman.

² Engr. Teresa Salangit. 2017. Phytoremediation schemes for polluted waterways in urban Areas. ERDB-THWRDE. Quezon City..

Zigzag

Scientific name: *Euphorbia tithymaloides* L.

Common name: Luha ng dalaga

Family name: Euphorbiaceae



Description:

- A succulent spurge whose distinctive shape makes it a fun houseplant.
- It can grow up to 3 feet in a pot.
- Leaves are medium to light green with pink and white variegation colors.
- This plant is moderately easy to care for if its basic cultural conditions are met.

Distribution:

- The plant is native to tropical and subtropical North America and Central America.

Propagation:

- The plants are grown from seeds and stem cuttings. It is easily propagated through stem cuttings even on ordinary soil.

Cultivation:

- The species is drought tolerant and suitable for landscaping. It can tolerate wide range of light conditions from full sun to deep shade.

Benefits/Uses:

- It absorbs sulfur dioxide in a polluted environment.¹
- It can also be a potential treatment for Dengue Virus, Leishma-niosis, Malaria, Schistosomiasis, Trypanosomiasis.²

¹ Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide. UP Diliman.

² Marcela Durán et.al. 2017. Silver Nanoparticles for Treatment of Neglected Diseases. Metal Nanoparticles in Pharma.

Canna Lily

Scientific name: *Canna indica* L.

Common name: Bandera española, Tikas

Family name: Cannaceae



Description:

- A perennial succulent herb with an unbranched stem.
- Leaves are oblong, acute or acuminate, bright green or tinged with maroon or red color.
- Flowers are irregular, showy, red, yellow, or pink, colored plain or with tiny blotches on petals.

Distribution:

- Used widely in Southeast Asian.

Propagation:

- The plant can be propagated from rooted cuttings of tip and also from suckers or offsets.

Cultivation:

- It grows well in moist loam soil with lots of sunlight. It can also tolerate partial shades and can be planted on a medium- sized container.

Benefits/Uses:

- Pandan plant can absorb sulfur dioxide chemicals present in the environment that are harmful to the human health.¹
- *Pandanus amaryllifolius* leaf extract, which has a polyphenol content of 102mg/g, exhibited an excellent heat-stable antioxidant property and may be a good natural alternative to existing synthetic antioxidants in the food industry.²

¹ Clementine Esguerra et al. 1982. Study on the uptake of sulfur dioxide and nitrogen dioxide. UP Diliman.

² Fatihanim Mohd Nor et.al. 2008. Antioxidative properties of Pandanus amaryllifolius leaf extracts in accelerated oxidation and deep frying studies.. Elsevier, Science Direct Food Chemistry.

Fragrant screw pine

Scientific name: *Pandanus amaryllifolius* Roxb.

Common Name: Pandan

Family name: Pandanaceae



Description:

- Tropical evergreen plant with fragrantly-scented leaves. It has two distinct growth forms namely:
 - a small growth form that grows from sucker shoots with slender stems
 - 1 - 1.6 meter tall and 2 - 5 centimeter in diameter
- Leaves are widely used as a food flavoring, and are commonly available in local markets.