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CRITICAL ANALYSIS OF PROTECTIVE ROLE OF PLANTS AGAINST GENTAMICIN INDUCED NEPHROTOXICITY

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Abstract

Nephrotoxicity is one of the most common kidney problems caused by variety of toxic compounds. Gentamicin (GM) is a broad spectrum aminoglycoside commonly used for controlling life threatening infections caused by Gram (+ve) and Gram (-ve) bacilli. However, it causes nephrotoxicity in about 15-30% of treated subjects. Because of superiority of gentamicin in controlling life threatening infections, scientific community is exploring renoprotective role of plant species to minimize gentamicin induced nephrotoxicity. In the present review, we have critically evaluated studies made for exploring renoprotective role of 2 species of algae, 3 of fungi, 1 of gymnosperm and 145 of angiosperms in the experimental animals exposed to gentamicin (GM). Histopathological findings of kidney are not considered in this review since these are merely descriptive (qualitative) and therefore, comparison among plant species is difficult for identifying the most promising renoprotective plant species. Ameliorating role of plant species has been considered in view of protection/recovery in the serum biochemical parameters deciphering kidney functions (urea, creatinine, uric acid, blood urea nitrogen) and oxidative stress (MDA/LPO, GSH/GPX, CAT, SOD). Out of 151species screened in the gentamicin treated animals, majority (108 species) were renoprotective (moderate – excellent) and reduce oxidative stress. It is likely that they differ in biomolecules. Plant species of excellent category may therefore, be explored for their ameliorative role to other nephrotoxicants both singly as well as in various combinations. The recommended dose of gentamicin for human is 20µg/kg body weight while several plant species were excellent in term of protection to experimental animals even at its higher doses (80-100mg/kg body weight), and therefore, there is a good scope for their clinical trials in the human beings treated with gentamicin. Presence of renoprotective properties among such a vast number of species highlights role of biodiversity in the welfare of mankind.

Key Words: Antioxidant, Creatinine, Gentamicin, Nephrotoxicant, Renoprotective plant species, Urea

Kidney is the only organ in the body that removes metabolic wastes such as urea, creatinine, uric acid etc. from the blood which are excreted through urine. Beside metabolic wastes; kidney also removes drugs and various toxic industrial and environmental agents in the blood. Because of increased blood flow (25% of the cardiac output) and presence of cellular transport systems within epithelial cells of the nephron, exposure to toxic substances is maximum in kidney. As a result, kidney related diseases are on rise particularly in the relatively more polluted areas.

Nephrotoxicity is one of the most common kidney problems with an estimated lifetime risk of 2-5% in Asia, 8-15% in Europe, America and around 20% in the Middle East. It reduces glomerular filtration rate that raises level of blood urea nitrogen (azotemia) and creatinine in the serum leading to increased retention of fluids in the body (over hydration) and blood pressure (hypertension).

The ability of kidney to concentrate tubular fluid contents is a hallmark of renal function. The nephrotoxic compounds damage epithelial cells of tubules; thereby reduce urine concentrating capacity or tubular proteinuria, lysosomal enzymuria and mild glucosuria, decrease ammonium excretion and increase hydrogen ion concentration in the blood (acidosis). The outcome is concentration gradient which favors influx of toxic compounds from the tubular fluid to the blood. This causes severe complications in the body such as edema, ascites, hepatomegaly etc. leading to acute renal failure.

The toxic compounds may be exogenous or endogenous. Radio contrast agents, aminoglycosides, antibiotics, chemotherapeutic agents, organic solvents, acetaminophen, illegal abortifacients, antineoplastic agents like cyclophosphamide, vincristin, cisplatin etc are important exogenous toxic agents. Their prolonged exposure may cause irreversible damage to renal system resulting in chronic renal failure (CRF), which led to permanent loss of excretory and endocrine functions of kidney.

Nephrotoxicants

Several toxicants may cause kidney failure. Following are some of the important nephrotoxic agents.

A) Metals & metalloid: Aluminum and its compound such as aluminum fluoride, Heavy metals such as mercury, cadmium, chromium, tin, lead, etc., and metalloid - arsenic

B) Antineoplastic agents

- **Alkylating agents:** Cisplatin, cyclophosphamide
- **Nitrosoureas:** Streptozotocin, carmustine, lomustine & semustine
- **Antimetabolites:** High doses of methotrexate, cytosine arabinose, 6-thioguanine, 5-flurouracil
- **Antitumor antibiotics:** Mitomycin, mithramycin, doxorubicin
- **Biologic agents:** Recombinant leukocyte and interferon

C) Antimicrobial agents: Tetracycline, acyclovir, pentamidine, sulphadiazine, trimethoprin, rifampicin, amphotericin-B

D) Aminoglycosides: Gentamicin, amikacin, kanamycin, streptomycin

E) Anti-cancer drugs

- Cyclosporine
- Cisplatin
- Cyclophosphamide
- Methanoglobin forming agents

F) Miscellaneous

- **Radiocontrast agents:** Non-steroidal anti-inflammatory agents (NSAID's), ibuprofen, indomethacin, aspirin etc.
- **Liquor consumption**

G) **Solvents and fuels**

- Carbon tetrachloride
- Methanol
- Amyl alcohol
- Glycol

G) **Environmental agents**

- Fluoride
- Acid rains

I) **Others**

- Herbicides
- Pesticides
- Diseases stimulating overproduction of uric acid

Mechanism of Nephropathy

Nephrotoxic agents damage tubular epithelial cells either by reacting directly with cellular macromolecules and membrane components or indirectly through their metabolism. Heavy metals (Hg, Pb), organic cations (spermine, cationic amino acids, amino glycosides) and polyene antibiotics (amphotericin) interacting respectively with sulfhydryl groups, membrane phospholipids and cholesterol cause direct damage whereas indirect damage is caused by metabolites (fluoride and oxalates) formed in hepatic metabolism of methoxyflurane intermediates of cisplastin, cystine conjugates, cephaloridine and acetaminophen. These toxic metabolites also generate free radicals.

Neprotoxicant accumulate mainly in the proximal tubular epithelial cells

Proximal straight (PT) and distal convoluted tubules (DT) of kidney are the major targets of toxicants since these accumulate in their epithelial cells. Because of brush border epithelial cells, PT absorbs and metabolizes toxicant more efficiently. This reduces exposure of DT cells to toxicant. Alterations in the DT cells are therefore, relatively less than that of proximal tubule cells (PT). The excessive injury in tubules lead to necrosis of tubular epithelial cells that significant increase urinary excretion of both brush border (alkaline phosphatase, g-glutamyl transferase) and intracellular enzymes (LDH, aspartate aminotransferase, alanine aminotransferase, and *N*-acetyl-b-D-glucosaminidase) (Agency for Toxic Substance and Disease Registry 1994, Gotelli et al. 1985, Guyton and Hall 2006, Planas-Bohne 1977, Price 1982, World Health Organization 1991, Zalups and Diamond 1987, Zalups et al. 1988, Zalups 1998).

Neprotoxicants also alter activity of many enzymes like acetyl cholinesterase, hexokinase, phosphor-oxidase and adenyl cyclase, aspartate aminotransferase (AST), alanine amino transferase (ALT), acid and alkaline phosphatase and phophorylase, lactate dehydrogenase (LDH), NADP (H) oxidase, lipases and phospholipases, creatinine phosphokinase etc.

Various studies have pointed out that nephrotoxicants increase oxidative stress either through excessive production of reactive oxygen species (ROS) such as superoxide radical (O_2^-), H_2O_2 and hydroxyl radical (OH^-) or disturb redox balance in the body by decreasing the activity of endogenous free radical scavengers such as superoxide dismutase, glutathione peroxidase and catalase. This leads to destruction of intracellular organelles, loss of microvilli, alterations in the number and size of the lysosomes and mitochondrial vacuolization followed by functional alterations such as DNA damage, inhibition of protein synthesis, glutathione depletion, lipid peroxidation and apoptosis. Because of excessive accumulation of free radicals, kidney loss copper and zinc that favor peroxidation of lipids and depletion of glutathione (Srinivasan et al. 2011, Ahmed and Sajida 2012, Ammar and Sabah 2013).

Na^+-K^+ ATPase and Ca^{+2}-Mg^{+2}ATPase pumps regulate urinary Na^+ and Ca^{+2} losses from serum. Neprotoxicant decreases activity of Na^+-K^+ ATPase and Ca^{+2}-Mg^{+2}ATPase pumps (Cittanova 2002, Anner and Moosmayer 1982, Anner et al. 1983, Imesch et al. 1992) and also alter membrane permeability. This may allow increased fluid uptake and its accumulation in cell vacuoles. Neprotoxicant also reduces reabsorption of number of plasma solutes such as glucose, amino acids, albumin, and other plasma proteins (Price 1982, Zalups and Diamond 1987, Zalups et al. 1998). The binding of different nephotoxicants with aquaporins blockade their function. Neprotoxicants render the collecting duct unresponsive to vasopressin or decrease vasopressin induced CAMP generation that leads to polyuria, polydipsia and weight loss (Turner et al. 1989, Yadav et al. 2016). Nephrotoxicant inhibits protein synthesis in the renal cells that induces necrosis of cells in the proximal tubule which can lead to acute renal failure (Sundin et al. 2001).

Gentamicin (GM) is a broad spectrum aminoglycoside commonly used for controlling life threatening infections caused by Gram (+ve) and Gram (-ve) bacilli. The epithelial cell linings of certain segments of the proximal renal tubules retain almost 5% of administered dose of gentamicin causing nephrotoxicity in about 15-30% of treated subjects evinced by increase in levels of creatinine, urea, uric acid/ blood urea nitrogen in the serum. Gentamicin also acts as an iron chelator and the iron-gentamicin complex is a potent catalyst of free radical generation resuting in oxidative stress. Because of superiority of gentamicin in controlling life threatening infections, scientific community is exploring ways to minimize gentamicin induced nephrotoxicity.

Medicinal Plants possessing nephroprotective activity

Therapeutic use of plants popular in underdeveloped and developing countries is now gaining acceptance worldwide because of its minimum/ almost nil side effects. Ayurveda is the medical science flourished in India in which ailments are cured with locally available medicinal plants. Because of diverse climate, India is a treasure of medicinal plants. Medicinal properties of plants are due to alkaloids, terpenoids, steroids, essentials oils and antioxidants such as vitamins, flavanoids, phenols etc. As stated earlier, neprotoxicants induces renal toxicity by increasing ROS generation and lipid peroxidation and therefore, medicinal plants rich in antioxidants may find application in minimizing neprotoxicant toxicity. Phytochemicals may also reduce levels of creatinine, urea, uric acid/ blood urea nitrogen in the serum and thereby improve GFR.

Scientists have explored nephroprotective role of plant species used since ages either by the locals or reported in Materia Medica of the ancient system of medication, other than conventional allopathic system of medication. In the present review, we have critically evaluated studies made for exploring renoprotective role of 2 species of algae, 3 of fungi, 1 of gymnosperm and 143 of angiosperms in the experimental animals exposed to gentamicin (GM).

Based on delivery of plant extract/powder (herbal preparation) to the experimental animals during the study, following 3 types of treatments were identified.

1. **Concomitant-** GM and herbal preparation were administered simultaneously. Herbal preparation given prior to GM exposure on the same day was also considered concomitant.

2. **Preventive-** Herbal preparation was administered to the experimental animals prior to entry into experimental protocol.
3. **Curative-** Herbal preparation was administered following GM exposure.

Histopathological findings of kidney are not considered in this review since these are merely descriptive (qualitative) and therefore, comparison among plant species is difficult for identifying the most promising renoprotective plant species. Ameliorating role of plant species has been considered in view of protection/recovery in the serum biochemical parameters deciphering kidney functions (urea, creatinine, uric acid, blood urea nitrogen) and oxidative stress (MDA/LPO, GSH/GPX, CAT, SOD). Further, protection level is classified in to following 6 grades.

A: Values of aforesaid parameters were almost similar to control {values of kidney markers and oxidative stress were higher (1-20%) than control values while of antioxidant levels were lower (1-20%)} than control.

B: Values of aforesaid parameters were more (21-30%) than control values for kidney markers and oxidative stress but lesser (21-30%) for antioxidant levels.

C: Values of aforesaid parameters were more (31-50%) than control values for kidney markers and oxidative stress but lesser (31-50%) for antioxidant levels.

D: Values of aforesaid parameters were more (51-70%) than control values for kidney markers and oxidative stress but lesser (51-70%) for antioxidant levels.

E: Values of aforesaid parameters were more (>70%) than control values for kidney markers and oxidative stress but lesser (>70%) for antioxidant levels.

Symbol $\mathbf{A^A}$ has been assigned to denote recovery in parameter/s even better than control; say for example when urea, creatinine and MDA/LPO levels were even lesser than control values and vice versa for antioxidants. The critical analysis of available data has been tabulated (Table 1-5). Based on quantum of serum biochemical data reported in various studies, data have been tabulated as follows.

1. Data on kidney functions + antioxidants levels at the termination of study
2. Data on kidney functions + antioxidants levels at different time intervals during the study period
3. Data on kidney functions at the termination of study
4. Data on kidney functions at different time intervals during the study period

Comparing values of serum biochemical parameters (denoting kidney functions, oxidative stress and antioxidant levels) in the gentamycin treated animals vis a vis control, following three categories were assigned to decipher ameliorating role of plant species.

1. **Excellent (E):** This includes plant species showing recovery of parameters in to 'A^A 'and 'A' grades.
2. **Good (G):** This includes plant species showing recovery of all parameters into 'A' grades.
3. **Moderate (M):** This includes plant species showing recovery of few parameters into either 'A^A 'or 'A' grade whereas of others in the lower grades. In case of only kidney parameters, one parameter may be of lower grade whereas for both kidney and oxidative stress parameters, two parameters may be of lower grade.
4. **Poor (P):** This includes plant species showing recovery of one parameter each of kidney function and oxidative stress into either 'A^A 'or 'A' grade whereas of others in the lower grades.

In majority of studies, optimum protection to the animals was accorded when gentamicin and herbal formulation were administered concomitantly. Normally renoprotection action of herbal formulation was dose dependent but an opposite trend was observed in few species.

- The protection/recovery of kidney functions and oxidative stress was moderate when algae and fungi were administered to the gentamicin treated animals (Table 1).
- The protection/recovery of kidney functions belonged to **excellent category** when plant parts of following plant species were administered to the gentamicin treated animals (Table 2-5).

Belowground organs

Root: *Croton zambesicus*, *Hemidesmus*, *Panax*, *Ipomea digitata*

Bulb: *Allium sativum*

Tuber: *Myrmecodia*

Aboveground organs

Leaf: *Casurina*, *Euclea*, *Psidium*, *Kalanchoe, Mentha* and *Moringa*

Shoot: *Eryngium*

Table 1. Ameliorative role of algae, fungi and gymnosperm on biochemical markers of kidney health and oxidative stress.

GM (mg/ Kg B. wt)	Plant	Herbal			Prognosis							References
		Prep-ration	Dose mg/kg B. wt	Protocol	Kidney functions			Oxidative stress				
					U	C	BUN/ UA*	LPO/ MDA*	GSH/ GPX*	CAT	SOD	
100 (1-7d)	*Spirulina platensis*	Whole plant	1000	Concomitant (1-7d)	D	A		D*	B/A*		A	Karadeniz et al. 2008a
80 (3-10d)	*Spirulina fusiformis*	Whole plant	500 1000 1500	Preventive (1-2d) + Concomitant (3-10d)		E E A	E E C			D C A	C B A	Kuhad et al. 2006
50 (1-6d)	*Morchella esculenta*	Mycelia: Hydro-ethan. Ext.	250 500	Concomitant (1-6d)	E C	E E		A* C*	A/B* C/A*	B A	B A	Nitha and Janardhanan 2008
100 (1-8d)	*Pleurotus porrigens*	Meth. Ext. (dried fruiting body)	200 400	Concomitant (1-8d) + Curative (9-10d)	D C	D B	A A^{A}					Moghaddam et al. 2010
100 (1-7d)	*Sacchar-omyces cerevisiae*	Whole plant	50% of diet	Curative (6-56d)	A^{A}	C	A*		C	C	B	EL-Ghany et al. 2012
80 (1-7d)	*Volvariella volvacea*	Fruiting body: Aqua Ext.	500 1000	Concomitant (1-7d)	A A	D A	E* B*		A/C* A/A*	A A	B A	Kalava and Menon 2012
80 (3-10d)	*Ginkgo biloba*	Leaf Ext. (Ranbaxy lab.)	300	Preventive (1-2d) + Concomitant (3-10d)	A^{A}	D		B*				Naidu et al. 2000
100 (1-8d)		Leaf : Etha. Ext.	200 400	Concomitant (1-8d)	E B	E B	D/C* C/A*					Mansoor et al. 2015

U = Urea, C = Creatinine, BUN = Blood urea nitrogen, UA = Uric acid, NA = Not available, Etha. = Ethanol, Ext.= Extract, d = day

Bark: *Spathodea* and *Cinnamomum zylenicum*

Gum: *Acacia senegal*

Fruit: *Solanum nigram*, *Citrus aurantium*, *Mangifera*

Seed: *Benincosa*, *Carica*, *Foenculum*, *Nigella*, *Trachyspermum*

Whole plant: *Hygrophila*, *Cuscuta*, *Kigelia*, *Morinda* and *Terminalia chebula*

Seeds of *Foeniculum* in combination with fruits of *Solanum nigrum* also protected kidney function under **excellent category**.

- The plant parts of following plant species protected/ recovered kidney functions to **good category** (Table 2-5).

Belowground organs

Root: *Cassia auriculata*, *Cyperus, Glycirrhiyza, Garcina kola*

Rhizome: *Zinziber*

Aboveground organs

Leaf: *Aloe*, *Aegle mermelos*, *Apium*, *Callestimon, Cynara*, *Urtica*, *Bryophyllum*, *Ficus carica*, *Sesbania grandiflora*

Shoot: *Phyllanthus flaternus*

Bark: *Ficus racemosa*

Flower: *Calotropis*, *Cocos nucifera*, *Crocus sativus*, *Punica*

Table 2. Ameliorative role of plant species on biochemical markers of kidney health.

GM (mg/ kg B. wt)	Plant	Herbal Prep.	Dose mg/kg B. wt	Protocol	Prognosis : Kidney functions U	C	BUN/ UA*	References
100 (1-7d)	*Abutilon indicum*	Root: Etha. Ext.	150	Concomitant (1-7d)		**E**	**A**	Jesurun and Lavakumar 2016
			300			**D**	**A**	
100 (1-8d)	*Acacia senegal*	Gum arabic: Aqua. Ext.	670	Concomitant (1-8)	**A**[A]	**A**		Tahir et al. 2016
80 (5-10d)			200	Preventive (1-4d) + Concomitant (5-10d)	**E**	E		Ali et al. 2003
80 (1-8d)	*Adhatoda zeylanica*	Leaf: Etha. Ext.	500	Curative (9 d -18d)	**E**	**A**[A]		Kumar et al. 2013
40 (1-13d)	*Aerva lanata*	Whole plant: Etha. Ext.	75	Curative (14-23d)	**E**	**E**		Shirwaikar et al. 2004
			150		**C**	**E**		
			300		**A**	**E**		
			300	Concomitant (1-13d)	**D**	**E**		
100 (3- 9d)	*Althaea officinalis*	Flower: Etha. Ext.	50	Preventive (1-2d) + Concomitant ($3-9^{th}$ d)	**E**	**E**		Talebi et al. 2014
			250		**E**	**E**		
			500		**E**	**E**		
100 (1-14d)	*Allium cepa*	Leaf: Etha. Ext.	200	Concomitant (1-14d)		**E**		Chinnala et al. 2017
			400			**E**		
120 (1-14d)	*Allium sativum*	Cloves: Aqua Ext.	4% of diet	Concomitant (1-14d)	**A**[A]	**A**		Seckiner et al. 2014
10 (1-10d)		Cloves: Etha. Ext.	20	Concomitant (1-10d)		**A**	**A**	Nasri et al. 2013
				Curative (11-20d)		**C**	**D**	
80 (1-7d)	*Aloe barbadensis*	Leaf: Aqua Ext.	100	Concomitant (1-7d)	**E**	**E**	**A**[*]	Chatterjee et al. 2012
			200		**C**	**E**	**A**[A*]	
80 (1-8d)	*Andrographis paniculata*	Root: Aqua Ext.	200	Concomitant (1-8d) + Curative (9-10d)	**A**	**A**	**C**	Singh et al. 2009
100 (1-8d)	*Bauhinia purpurea*	Leaf: Etha. Ext.	300	Concomitant (1-8d)	**D**	**E**	**D/B**[*]	Laxmi et al. 2009
		Unripe Pod: Etha. Ext.			**B**	**B**	**A/A**[*]	

100 (1-8d)	*Bauhinia variegata*	Fruit: Aqua Ext.	200	Concomitant (1-8d)	**E**	**E**	**E**	Sharma et al. 2011
		Fruit: Etha.			**C**	**E**	**E**	
		Fruit: Aqua	400		**E**	**E**	**E**	
		Fruit:Etha.			**A**	**C**	**C**	
		Leaf : Meth. Ext	400	Concomitant (1-8d)	**A**	**B**	**A/A***	Prusty et al. 2012
80 (1-6d)	*Benincosa hispida*	Seed : Etha. Ext.	250	Concomitant (1-6d)	**A^A**	**E**		Qadrie et al. 2013
			500		**A^A**	**A**		
80 (1-10d)	*Boerhavia diffusa*	Himalaya capsule Plant Ext.	400	Curative (11-74d)	**E**	**E**	**E^***	Padmini and Kumar 2013
			800		**C**	**C**	**C^***	
80 (1-8d)		Root	4g/kg	Concomitant (1-8d) + Curative (9-21d)	**A**	**E**		Kulkarni et al. 2012
				Curative (9-21d)	**A**	**A**		
100 (1-8d)	*Boswellia serrata*	Gum: Aqua extract	1000	Concomitant (1-8d)		**D**	**E**	Alam et al. 2011
		Metha. solub. (MS)	650 (MS)			**C**	**E**	
		Insolu. (MINS)	350 (MINS)			**C**	**E**	
80 (1-16d)	*Bryophyllum pinnatum*	Leaf:Etha. Ext.	150	Concomitant (1-16d)	**A**	**A**		Sule and Arhoghro 2016a
			300		**A**	**A**		
40 (1-14d)	*Carica papaya*	Seed:Aqua Ext.	200	Concomitant (1-14d)		**A^A**	**A/A***	Nale et al. 2012
40 (1-13d)	*Cassia auriculata*	Root: Etha. Ext.	600	Concomitant (1-13d)	**A**	**A**		Annie et al. 2005
			600	Curative (14-23d)	**A**	**A**		
100 (1-8d)	*Camellia sinensis*	Leaf:Etha. Ext.	300	Preventive (1-7d) + Concomitant (8-15d)	**C**	**E**		Veljković et al. 2015
80 (1-7d)	*Caesalpinia bonduc*	Leaf:Metha Ext.	250	Concomitant (1-7d)	**E**			Noorani et al. 2011
			500		**D**			
100 (1-8d)	*Callestimon viminalils*	Leaf: Hydro-metha. Ext.	250 500	Concomitant (1-8d)	**A**	**A**	**A/A***	Sallem et al. 2016

80 (1-21d)	*Cinnamomum tamala*	Leaf: Etha. Ext.	200	Concomitant (1-21d)		**D**	A/A^{*}	Ullah et al. 2013a
100 (1-28d)	*Cinnamomum zeylanicum*	Peel powder: Etha. Ext.	50 100 200	Concomitant (1-28d)		**B** A^{A} A^{A}	E/D^{*} E/A^{*} A/A^{*}	Tanomand and Najafian 2013
80 (1-21d)	*Citrullus colocynthis*	Whole plant: Etha. Ext.	25	Concomitant (1-21d)		**E**	E/D^{*}	Ullah et al. 2013b
80 (1-7)	*Cola nitida*	Fruit: Aqua Ext.	200 500	Concomitant (1-7d)	**E** **E**	**E** **D**		Abou et al. 2016
		Fruit: Etha. Ext.	200 500		**E** **E**	**E** **D**		
90 (1-7d)	*Costus afer*	Leaf: Aqua Extra.	375 750 1125	Concomitant (1-7d)	A^{A} **E** A^{A}	**E** **E** **E**		Ezejiofor et al. 2014
100 (1-10d)	*Curcuma longa* (CL)	Rhizome: Curcumin pigment	200	Concomitant (1-10d)	C	A	D^{*}	Azab et al. 2014
75 + 75 at 12h interval			400	Preventive (1-5d)+ Concomitant (6-12d)		E	**E**	Negrette-Guzmán et al. 2015 In vitro study
80 (1-6d)	*Crocus sativus*	Safranal: Aqua extract	0.5mL/kg B.wt.	Concomitant (1-6d)	**A**	**A**		Boroushak and Sadeghnia 2009
80 (1-14d)		Petal: Hydro Etha. Ext.	40 80	Concomitant (1-14d)		**C** **E**	C/A^{*} E/A^{*}	Omidi and Torabi 2016
80 (7-14d)			80	Preventive (1-6d)		**D**	D/A^{*}	
100 (1-10D)		Saffron: Aqua extract	5	Concomitant (1-10d)		**E**	**E**	Derakhshanfar et al. 2015
40 (1-10d)		Stigma: Etha. Ext.	50	Concomitant (1-10d)		**A**	**A**	Dhar et al. 2013
100 (1-8d)	*Croton zambesicus*	Root: Etha. Ext.	27 54 81	Concomitant (1-8d)	A^{A} A^{A} A^{A}	A^{A} A^{A} A^{A}	A^{*} A^{*} A^{*}	Okokon et al. 2011
100 (1-8d)	*Cuscuta reflexa*	Whole plant: Hydro metha. Ext.	200 400 600	Concomitant (1-8d)	**A** **A** **A**	**A** A^{A} A^{A}	C/C^{*} B/C^{*} A/A^{*}	Alamgeer et al. 2017
100 (1-12d)	*Dalbergia sissoo*	Leaf: Etha. Ext.	100 200	Concomitant (1-12d)	**C** **B**	**C** **A**	E^{*} C^{*}	Saxena et al. 2016

100 (1-8d)	*Daucus carota*	Root: Etha. Ext.	200 400	Concomitant (1-8d)	**C** **A**	**E** **C**	**C/C*** **B/B***	Sodimbaku et al. 2016
80 (1-5d)	*Echinodorus macrophyllus*	Leaf : Etha. Ext.	30	Concomitant (1-5d)		**C**		Portella et al. 2012
80 (1-7d)	*Elephantopus scaber*	Leaf: Etha. Ext.	200 400 600	Concomitant (1-7d)	E D A	E E E		Sahoo et al. 2012
80 (1-8d)	*Elettaria cardmomum*	Seed: Aqua Ext.	100 200	Curative (9-21d)	**C** **A**	**D** **C**		Elkomy et al. 2015
80 (1-7d)	*Entandrophra gmaangolense*	Bark : Aqua Ext.	200 500	Concomitant (1-7d)	**E** **E**	**E** **D**		Abou et al. 2016
		Bark: Etha. Ext.	200 500		**E** **E**	**E** **D**		
100 (1-10d)	*Eryngium caucasicum*	Shoot: Hydro-metha. Ext.	200 400	Concomitant (1-10d)	**B** **A^A^**	**B** **A**	**C** **A^A^**	Eslami et al. 2011
200 (1-8d)	*Ficus carica*	Leaf: Etha. Ext.	400	Concomitant (1-8d)	**A**	**A**		Ghafoor et al. 2015
80 (1-14)	*Garcina kola*	Root: Metha.	250	Concomitant (1-14d)	**A**	**A^A^**	**B***	Komolafe et al. 2016
		Dichlo. methane fraction			**A**	**A^A^**	**B***	
80 (1-7d)	*Gomphrena celosioides*	Aqua. Ext. (Leaf + Stem + Flower)	200 500	Concomitant (1-7d)	**E** **E**	**E** **D**		Abou et al. 2016
		Etha. Ext. (Leaf + Stem + Flower)	200 500	Concomitant (1-7d)	**E** **E**	**E** **D**		
90 (1-6d)	*Hemidesmus indicus*	Root Powder	5000	Curative Male (7-12d) Female		**A** **A**	**A** **A^A^**	Kotnis et al. 2004
80 (7-14d)	*Ipomoea aquatica*	Leaf: Etha. Ext.	500	Preventive (1- 6d)	**D**	**A**		Sharmin et al. 2016
40 (1-14d)	*Jasminum grandiflorum*	Leaf: Meth. Ext.	100 200	Concomitant (1-14d)	**E** **D**	**E** **D**	**E/E*** **C/C***	Venkataiah et al. 2013

100 (4-8d)	*Khaya senegalensis*	Stem bark: Aqua. Ext.	250	Preventive (1- 3d) + Concomitant (4-8d)	**E**	**A**[A]		El Badvi et al. 2012
			500		**E**	**C**		
80 (1-7d)	*Kigelia africana*	Whole plant: Metha. Ext.	100	Concomitant (1-7d)	**A**[A]	**A**		Hoque et al. 2016
			200		**C**	**E**		
100 (1-8d)	*Kalanchoe pinnata*	Leaf : aqua Ext.	125	Concomitant (1-8d)	**A**	**A**[A]	**A/A***	Harlalka et al. 2007
80 (1-8d)	*Lagenaria siceraria*	Seed: Metha. Ext.	250	Concomitant (1-8d)		**A**	**B/A***	Mahurkar et al. 2012
		Seed: Aqua. Ext.	250			**A**	**A/A***	
100 (1-7d)	*Lantana camara*	Root: Etha. Ext.	200	Concomitant (1-7d)	**E**	**E**	**C**	Vyas and Argal 2012
40 (1-14d)	*Momordica charantia*	Leaf : Hydro-Etha. Ext.	100	Concomitant (1-14d)	**E**	**E**		Chawari et al. 2011
			200		**E**	**D**		
100 (1-10d)	*Morinda citrifolia*	Ext.	500	Concomitant (1-10d)	**A**[A]	**A**[A]		Anitha and Dass 2014
100 (1-12d)	*Nelumbo nucifera*	Root: Etha. Ext.	100	Concomitant (1-12d)	**A**	**A**	**B***	Dubey et al. 2014
		Flower: Etha. Ext.	100		**B**	**B**	**E***	
		Leaf : Etha. Ext.	100		**B**	**C**	**D***	
180	*Ocimum sanctum*	Leaf: Aqua. Ext.	100			**A**		Kumar et al. 2014
100 (1-10d)	*Panax ginseng*	Root	100	Concomitant (1-10d)	**D**	**E**	**A**	Kalkan et al. 2012
			200		**A**[A]	**A**	**A**	
80 (1- 15d)			100	Concomitant (1- 15d)	**C**	**B**		Qadir et al. 2011
80 (22-28d)		Red ginseng (root)	100	Preventive (1-21) + + Concomitant (22-28d)		**A**	**A**[A]	Lee et al. 2013
40 (1- 12d)	*Physalis alkekengi*	Fruit: Etha. Ext.	450	Concomitant (1- 12d)	**B**	**E**		Ahmad et al. 2010
40 (1- 5d)				Curative (6- 12d)	**C**	**E**		

80 (21st d)	*Phyllanthus amarus*	Leaf: Etha. Ext.	200 300	Preventive (1- 20d)		**A** **B**		Sule and Arhoghro 2016b
40 (1- 14d)		Whole plant: Aqua Ext.	100 200 400	Concomitant (1- 14d)	**E** **E** **D**	**E** **D** **A**		Adeneye and Benebo 2008
80 (4-11d)		Seed: Meth. Ext. Seed: Aqua. Extract	250 300	Preventive (1- 3d) + Concomitant (4- 11d)	**A** **E**	**A** **B**		Bakhtiary et al. 2012
100 (1- 10d)	*Phyllanthus acidus*	Leaf : Meth. Ext.	50 100 200	Concomitant (1- 10d)	**E** **E** **E**	**A** **A** **A**		Vidya et al. 2013
80 (1-9d)	*Phyllanthus niruri*	Whole plant : Meth. Ext	200 400	Curative (10-19d)	**C** **B**	**A** **A**	**A** **A**	Gaddam et al. 2015
80 (1-8d)	*Phyllanthus fraternus*	Shoot : Meth. Ext.	100 200	Curative (9-16d)		**E** **A**	**D** **A**	Kalyani et al. 2012
80 (1-8d)			200	Concomitant (1- 8d)		**B**	**B**	
100 (1- 8d)	*Pimpinella anisum*	Shoot : Eth. Ext.	300	Concomitant (1- 8d)		**E**	**E**	Ashtiyani et al. 2017
80 (8-14d)	*Piper cubeba*	Berry (Dry) Powder	810 1220	Preventive (1-7d) + Concomitant (8-14d)	**C** **C**	**E** **C**		Zaid et al. 2012
80 (1-7d)			810 1220	Curative (8-14d)	**C** **E**	**C** **C**		
40 (1-13d)	*Pongamia pinnata*	Flower: Eth. Ext.	600	Concomitant (1-13d) Curative (14-23d)	**C** **B**	**A** **A**		Shirwaikar et al. 2003
100 (1-8d)	*Punica granatum*	Fruit: Aqua ext.	100	Concomitant (1-8d) Concomitant (8th d)	**B** **E**	**D** **E**	**B*** **A***	Ali and Saeed 2012
100 (4-8d)	*Rheum emodi*	Revand Hindi (drug): Metha. Ext.	350 - Water solu. 350 - Water insolu.	Preventive (1-3d) + Concomitant (4-8d)	**D** **A**	**D** **D**		Alam et al. 2005

100 (1-8d)	*Rubus ellipticus*	Fruit: Pet. Ether Ext.	200	Concomitant (1-8d)	**C**	**A**	**E**	Sharma and Kumar 2011
		Fruit: Etha. Ext.			**A**	**A**	**A**	
		Fruit: Aqua Ext.			**A**	**A**	**C**	
100 (1-10d)	*Rosmarinus officinalis*	Leaf : Aqua Ext.	220	Concomitant (1-10d)	**A**	**A**^{A}	**C***	Azab et al. 2014
80 (1-21d)	*Rosa damascene + Cichorium intybus*	Flower (Rosa) + Root (Cichorium): Aqua Ext.	250 (RD)	Concomitant (1-21d)	**E**	**E**	**E**	Khaliq et al. 2014
			500 (RD)		**E**	**E**	**E**	
			250 (CI)		**E**	**E**	**E**	
			500 (CI)		**E**	**E**	**E**	
			250 (RD) +250 (CI)		**E**	**E**	**E**	
			500 (RD) + 500 (CI)		**C**	**D**	**E**	
80 (1-10d)	*Sesbania grandiflora*	Leaf : Aqua Ext.	300	Concomitant (1-10d)	**A**	**A**	**A***	Padmalochana and Dhana rajan 2015
		Leaf: Etha. Ext.			**A**	**A**	**A***	
		Leaf : Acetone Ext.			**A**	**A**	**A***	
100 (1-10d)	*Strychnos potatorum*	Seed: Etha. Ext.	100	Concomitant (1-10d)	C	E		Varghese et al. 2011
			200		**A**	**B**		
			300		**A**	**B**		
80 (1-21d)	*Tamarindus indica*	Fruit: Hydro-Etha. Ext.	200	Concomitant (1-21d)		**C**	**A/A***	Ullah et al. 2014b
80 (1-7d)	*Tecoma stans*	Flower: Etha. Ext.	500	Concomitant (1-7d)	**E**	**C**	**A**^{A*}	Mohan et al. 2016
80 (1-8d)		Flower: Ethyl acetate Ext.	100	Concomitant (1-8d)	**C**	**E**	**D/A***	Raju et al. 2011
			200		**B**	**E**	**C/A***	
			300		**A**	**E**	**A/A***	

80 (1-7d)	*Terminalia chebula*	Aqua Ext.	125 250	Concomitant (1-7d)		**A** **A**	**A** **A**	Sivachandran and Hariharan 2012
80 (1-7d)	*Trema guineensis*	Leaf: Hydro hydro Etha. Ext.	100 200	Concomitant (1-7d)	**B** **B**	**C** **C**		Cyril et al. 2016
		Leaf : Aqua extract	100 200		**A** **A**	**C** **C**		
100 (1-14d)	*Trianthema portulacastrum*	Leaf : Etha. Ext.	200	Concomitant (1-14d)	**A**	**A**[A]	**B**	Balamurugan et al. 2009
80 (1-8d)	*Tribulus terrestris*	Fruit: Aqua ext. (Kwath)	4000	Concomitant (1-8d) + Curative (9-21d)	**D**	**E**		Kulkarni et al. 2012
				Curative (9-21d)	**A**	**E**		
100 (61-68d)	*Vitis vinifera*	Seed: n-Hexane & Meth. Ext.	40	Preventive (1-60d) + Concomitant (61-68d)		**E**	**E**	Safa et al. 2010
100 (15-22d)	*Withania somnifera*	Root : Meth. Ext.	500	Preventive (1-14d) + Concomitant (15-22d)	**B**	**B**		Choudhury et al. 2014
100 (1-8d)	*Zea mays*	Shoot: Meth. Ext.	200 300 400 500	Concomitant (1-8d)	**E** **E** **E** **E**	**C** **D** **E** **E**		Sepehri et al. 2009

Table 3. Effects of herbal extracts on the recovery of biochemical markers of kidney health at different time intervals.

GM (mg/kg B. wt)	Plant	Herbal Prep.	Dose mg/kg B. wt	Protocol	Day/ Week	Prognosis: Kidney functions U	C	BUN/UA	References
80 (6-10d)	*Aloe barba-densis*	Leaf: Ethan. Extr.	20mL + 20mL = 40mL	Preventive (1-5d) + Concomitant (6-10d)	10d		**D**	**D**	Virani et al. 2016
80 (16-20d)				Preventive (1-15d) + Concomitant (16-20d)	20d		**A**	**B**	
80 (26-30d)				Preventive (1-25d) + Concomitant (26-30d)	30d		**A**	**A**	
80 (1-21d)	*Citrus aurantium*	Fruit: Etha. Ext.	200	Concomitant (1-21d)	1d		**A^{A}**	**A^{A}/A***	Ullah et al. 2014a
					11d		**A**	**A^{A}/A***	
					21d		**B**	**A^{A}/A***	
100 (11-18d)	*Mangifera indica*	Fruit: Vimang (Comm-ercial Ext.)	50	Preventive (1-10d) + Concomitant (11-18d)	11d	**C**	**A**		Rad et al. 2011
					18d	**E**	**D**		
			100		11d	**C**	**A**		
					18d	**E**	**D**		
		Fruit: Hydro-alcoholic Ext.	200		11d	**A^{A}**	**A**		
					18d	**A**	**A^{A}**		
			400		11d	**A**	**C**		
					18d	**C**	**A^{A}**		
100 (11-18d)		Fruit: Vimang	100	Concomitant (11-18d)	11d	**A^{A}**	**A**		
					18d	**E**	**E**		
		Fruit: Hydro-alcoholic Ext.	400		11d	**A^{A}**	**A**		
					18d	**D**	**A^{A}**		
80 (1-21d)	*Mentha piperita*	Leaf : Etha. Ext.	200		0d		**A^{A}**	**A^{A} /A***	Ullah et al. 2013c
				Concomitant (1-21d)	11d		**A^{A}**	**A^{A} /A***	
					21d		**B**	**A^{A} /A***	
80 (1-10d)	*Moringa oleifera*	Leaf : Hydro-Etha. Ext.	150	Concomitant (1-10d)	0d	**A^{A}**	**A**		Ouédraogo et al. 2013
					4d	A	**A**		
			300		7d	C	**B**		
					10d	E	**B**		
					0d	**A^{A}**	**A^{A}**		
					4d	A	**A^{A}**		
					7d	B	**C**		
					10d	**C**	**A**		
80 (1-21d)	*Morus alba*	Fruit : Etha. Ext.	200	Concomitant (1-21d)	0d		**A**	**A/A***	Ullah et al. 2015
					11 d		**B**	**A/A***	
					21 d		**D**	**B/A***	
100 (1-7d)	*Myrme-codia tuberose*	Tuber : Aqua Ext.	1000	Concomitant (1-7d)	0 d		**A**	**A**	Sujono et al. 2014
					7 d		**E**	**E**	
			2000		0 d		**A**	**A**	
					7 d		**B**	**C**	
			4000		0 d		**B**	**A**	
					7 d		**B**	**C**	

80 (1-26d)	*Nigella sativa*	Seed oil	2mL/kg	Concomitant (1-26d)	1d	$\mathbf{A}^{A}$	**B**	Rehman et al. 2012
					10 d	**A**	**A**	
					14 d	$\mathbf{A}^{A}$	**B**	
					18 d	$\mathbf{A}^{A}$	$\mathbf{A}^{A}$	
					22 d	$\mathbf{A}^{A}$	**A**	
					26 d	$\mathbf{A}^{A}$	**A**	
80 (1-10d)				Curative (11-26d)	1d	$\mathbf{A}^{A}$	**E**	
					10 d	**E**	**E**	
					14 d	**E**	**C**	
					18 d	**D**	**C**	
					22 d	**C**	**D**	
					26 d	**C**	**A**	
80 (1-26d)		Seed oil	2mL /kg	Concomitant (1-26d)	0d	$\mathbf{A}^{A}$	**C**	Saleem et al. 2012
					4d	**C**	**A**	
					8d	$\mathbf{A}^{A}$	**A**	
					12d	$\mathbf{A}^{A}$	$\mathbf{A}^{A}$	
					16d	$\mathbf{A}^{A}$	**A**	
					20d	$\mathbf{A}^{A}$	**A**	
10 mM (31-40d)	*Panax ginseng*	Root: Aqua Ext.	100	Preventive (1-30d) + Concomitant (31-40d)	3d	**A**	**A**	Shin et al. 2014
					10d	**E**	**E**	
80 (1- 6d)	*Phoenix dactylifera*	Fruit flesh : Aqua Ext.	50% of diet	Concomitant (1- 6d)	6d	**A**	**A**	Al-Qarawi et al. 2008
				Preventive (1- 22d) + Concomitant (23- 28d)	28d	**A**	**A**	
		Pits: Aqua Ext.	Drin-king water (2:1)	Concomitant (1- 6d)	6d	**A**	**A**	
				Preventive (1- 22d) + Concomitant (23- 28d)	28d	**A**	**A**	

Table 4. Ameliorative role of plant species on biochemical markers of kidney health and oxidative stress.

Dose mg/kg B. wt	Plant	Herbal: Prep.	Herbal: Dose mg/kg B. wt	Herbal: Protocol	Prognosis: Kidney functions: U	C	BUN /UA*	Oxidative stress: LPO/ MDA*	GSH/ GPX*	CAT	SOD	References
100 (9-16d)	*Aegle marmelos*	Leaf: Aqua Ext.	250	Preventive (1-8d) + Concomitant (9-16d)	**E**	**E**	**E**	**E***	**D**	**D**		Kore et al. 2011a
			500		**D**	**C**	**D**	**C***	**C**	**D**		
			750		**A**	**A**	**A**	**A***	**B**	**B**		
40 (1- 13d)	*Alangium salvifolium*	Bark: Ethan. Ext.	250	Concomitant (1-13d) + Curative (14-21d)		**E**	**D**	**B***	**D**	**B**		Geetha and Ramarao 2014
			500			**B**	**E**	**A***	**D**	**A**		
			750			**E**	**A**	**A***	**A**	**A**		
			750			**E**	**A**	**C***	**D**	**A**		
80 (1-14d)	*Allium sativum*	Clove: Aqua Homo.	500	Concomitant (1-14d)				**D***	**B***			Fadil et al. 2016
80 (NA)	*Amorpho-phallus paeoniifolius*	Corm: Metha. Ext.	250	Not available	**E**	**D**		**C**	**B**			Madhurima 2010
			500		**C**	**A**		**A**	**A**			
100 (1- 7d)	*Apium graveolens Var. rapaceum*	Dry powder of Celery	5% of diet	Curative (8-56d)	**A**	**A**	**A***		**C** *	**C**	**C**	El-Ghany et al. 2012
40 (1-14D)	*Aristolochia indica*	Leaf: Ethan.Ext.	500	Concomitant (1-14d)	**A**^{A}	**C**		**A***	**C/A***	**A**	**A**	Arivazhagan and Vimala-stalin 2014
40 (1- 30d)	*Asarum europaeum*	Leaf: Ethan. Ext.	200	Concomitant (1- 30d)	**C**	**E**		**E***		**D**	**C**	Mamilla-pallai and Akkiraju 2015
			400		**B**	**E**		**C***		**C**	**B**	
80 (1-15d)	*Bacopa monniera*	Shoot: Ethan. Ext.	100	Concomitant (1-15d)	**A**	**A**	**C***		**B/A***	**B**	**B**	Kannan et al. 2011
			200		**A**^{A}	**A**	**C***		**A/A***	**A**	**A**	
80 (1-7d)	*Barringtonia acutangula*	Leaf : Metha. Ext.	200	Concomitant (1-7d)	**E**	**E**		**E**	**B***	**B**	**D**	Mishra et al. 2014
80 (1-8d)	*Bauhinia purpurea*	Bark: Eth. Ext.	400	Concomitant (1-8d)	**E**	**E**		**E***	**C**		**C**	Rana et al. 2014
		Unripe Pod: Eth. Ext.			**E**	**E**		**E***	**C**		**C**	
85 (21-28d)	*Beta vulgaris*	Root : Eth. Ext.	250	Preventive (1-20d) + Concomitant (21-28d)	**E**	**E**	**E***	**E***		**A**		EL Gamal et al. 2014
			500		**E**	**E**	**E***	**E***		**A**		
80 (1-14d)	*Calotropis procera*	Flower: Aqua Ext.	150	Concomitant (1-14d)	**B**	**A**				**A**		Javed et al. 2015
			300		**A**	**A**				**A**		
80 (1-6d)	*Casuarina equisetifolia*	Leaf: Metha. Ext.	300	Curative (7-35d)	**C**	**A**	**A**^{A*}	**A***	**A**		**A**	El-Tantawy et al. 2013
80 (29-34d)			300	Preventive (1-28d)	**A**	**A**	**A**^{A*}	**A***	**A**		**A**	

100 (50 + 50 twice) (1-15d)	*Camellia sinensis*	Tablet of green tea Ext.	300	Concomitant (1-15d) + Curative (16-30d)		**C**	**C**		**A**	**A**		Salem et al. 2010
80 (1-7d)		Leaf: Metha. Ext.	300	Concomitant (1-7d)		**E**	**B**		**A**	**A**	**A**	Khan et al. 2009
80 (15-22d)	*Citrus medica*	Fruit : Etha. Ext.	250 500	Preventive (1-14d) + Concomitant (15-22d)	**E** **E**	**D** **C**	**E*** **E***	**E*** **E***				AL-Yahya et al. 2015
100 (1-24d)	*Cocos nucifera*	Milk	1mL/ day	Concomitant (1-24d)	**A**	**A**		**A***		**A**	**A**	Ehimigbai and Ananobi 2015
80 (1-16d)		Inflo. sap powder	20	Concomitant (1-16d)	**A**	**A**	**A***		**B/A***	**A**	**A**	Jose et al. 2017
80 (10-19d)	*Cucumis sativus*	Seed: Hydro-ethanolic Ext.	200 400	Preventive (1-9d)		**E** **C**	**D** **B**	**E** **E**	**D** **C**	**D** **B**	**C** **B**	Pransanthi and Adikay 2016
80 (1-9d)			200 400	Curative (10-19d)		**D** **A**	**C** **A**	**E** **D**	**D** **A**	**C** **A**	**C** **B**	
100 (8-15d)	*Curcuma longa* (CL)	Rhizome: Curcu-min	200	Preventive (1-7d) + Concomitant (8-15d) + Curative (16-57d)		**B**	**A**		**A/A***	**A**	**A**	El-Zawahry and Kheir 2007
80 (5-10d)			200	Preventive (1-4d) + Concomitant (5-10d)	**C**	**B**			**A**		**A**	Ali et al. 2005
100 (8-15d)			100	Preventive (1-7d) + Concomitant (8-15d)	A	B		**A***		**A**		Bayomy et al. 2011
100 (15-21d)			200	Preventive (1-14d) + Concomitant (15-21d)	B	B		**E***	**A/A***	**A**	A	Farombi and Ekor 2006
100 (1-7d)	**CL**	Powder with diet	5%	Curative (8-56d)	A	B	**E***		**B***	**C**	B	El-Ghany et al. 2012
80 (36-42d)	**CL**	Rhizome powder: Aqua Ext.	150	Preventive (1-35d) + Concomitant (36-42d)	**B**	A	**A***	**A^{A*}**	**B/C***	**B**	**A**	Shalaby & Hammouda 2014
	Eruca sativa (ES)	Seed: Aqua Ext.	150		**B**	**A**	**A***	**A***	**A/B***	**A**	**A**	
	Petroselinum	Seed:	150		**B**	**A**	**A***	**A^{A*}**	**C/C***	**C**	**B**	

	CL + PS + ES	As above	50+50 +50		**A**	**A^{A}**	**A^{*}**	**A^{*}**	**A/A^{*}**	**A**	**A**	
100 (6-12d)	*Crocus sativus*	Pigment crocin: Aqua extract	100	Preventive (1-5d) + Concomitant (6-12d)		**E**	**E**	**A^{*}**				Yarijani et al. 2016
80 (6-10d)		Saffron: Aqua Ext.	40	Preventive (1-5d) + Concomitant (6-10d)		**D**	**E**	**E^{*}**				Ajami et al. 2010
			80			**C**	**C**	**C^{*}**				
100 (1-10d)	*Cynara scolymus*	Leaf: Aqua Ext.	200	Concomitant (1-10d)		**B**	**C/B^{*}**	**B**				Khattab et al. 2016
			400			**A**	**A/A^{*}**	**A^{*}**				
			600			**A**	**A^{A}/A^{*}**	**A^{*}**				
100 (4-10d)	*Cyperus scariosus*	Root : Hydro alcoholic Ext.	150	Preventive (1-3d) + Concomitant (4-10d)	**E**	**E**		**E^{*}**	**A**		**E**	Gajjar et al. 2016
100 (1-7d)				Curative (8-18d)	**A**	**A**		**E^{*}**	**E**		**D**	
100 (4-10d)			250	Preventive (1-3d) + Concomitant (4-10d)	**E**	**E**		**C^{*}**	**C**		**D**	
100(1-7d)				Curative (8-18d)	**A**	**B**		**A^{*}**	**E**		**D**	
100 (3-10d)	*Euclea divinorum*	Leaf: Crude Ext.	100	Preventive (1-2d) + Concomitant (3-10d)		**D**	**A**	**A^{*}**	**A**	**A**	**A**	Feyissa et al. 2013
			150			**E**	**C**	**A^{*}**	**A**	**A**	**A**	
			200			**E**	**D**	**A^{*}**	**A**	**C**	**A**	
		Metha. fraction	100			**B**	**A**	**A^{*}**	**A**	**A**	**A**	
		Aqua fraction	100			**A^{A}**	**A**	**A^{*}**	**E**	**B**	**A**	
100 (1-6d)	*Elaeocarpus ganitrus*	Seed: Etha. Ext.	100	Concomitant (1-6d)		**E**	**E/A^{*}**		**C**	**A**	**A**	Kakalij et al. 2014
			200			**E**	**D/A^{*}**		**B**	**A**	**B**	
			400			**D**	**A/A^{A*}**		**A**	**A**	**C**	
80 (1-8d)	*Enicostemma littorale*	Whole plant Metha. Ext.	2500	Concomitant (1-8d)		**E**	**D**	**D^{*}**	**E/C^{*}**	**A**	**A**	Bhatt et al. 2011
120 (1-7d)	*Ferulago angulata*	Whole plant : Hydro-Etha. Ext.	200	Concomitant (1-7d)	**E**	**E**	**E^{*}**	**E^{*}**		**C**	**C**	Valipour et al. 2016
			400		**E**	**A^{A}**	**D^{*}**	**E^{*}**		**C**	**E**	
			800		**C**	**E**	**B^{*}**	**A^{*}**		**A**	**B**	
80 (1-21d)	*Foeniculum vulgare* (FV) & *Solanum nigrum (SN)*	Seeds of FV and Fruits of SN	250 (FV)	Concomitant (1-21d)	**A**	**A**		**E^{*}**		**B**		Shaheen et al. 2014
			250 (SN)		**A**	**A**		**E^{*}**		**B**		
			500 (FV)		**A^{A}**	**A**		**C^{*}**		**A**		
			500(SN)		**A^{A}**	**A**		**D^{*}**		**A**		
			250 (FV) + 250 SN)		**A**	**A**		**D^{*}**		**B**		
			500 (FV) + 500 (SN)		**A^{A}**	**A^{A}**		**A^{*}**		**A**		

200 (1-8d)	*Ficus carica*	Fruit: Hydro- Etha. Ext.	250 500 750	Concomitant (1-8d)	**E** **D** **A**	**E** **C** **A**	**E** **D** **A**	**E*** **C*** **A***	**D** **C** **B**	**D** **D** **B**		Kore et al. 2011b
80 (1-11d)	*Ficus racemosa*	Bark: Aqua Ext.	200 400	Concomitant (1-11d)	**A** **A**	**A** **A**		**A** **A**	**A** **A**	**C** **C**	**C** **C**	Shivalinge and Vrushaben-dra 2012
80 (1-12d)	*Glycine max*	Seed: Phenolic ext.	500 1000	Concomitant (1-12d)	**A** **A**	**A** **A**			**A** **E**		**B** **A**	Ekor et al. 2006
100 (8-12d)	*Glycyrrhiza glabra*	Capsule	150	Preventive (1-7d)		**A**	**A/A***	**A***	**C**			Yousef and Alkreathy 2016
40 (1-13d)	*Grapto-phyllum pictum*	Leaf: Phenolic Ext.	75 150 300	Curative (14-23d)	**A** **A** **A**	**E** **E** **E**		**A** **A** **A**		**A** **A** **A**	**E** **A** **A**	Srinivasan et al. 2015
100 (1-12d)	*Houttuynia cordata*	Leaf : Metha. Ext.	500 1000	Concomitant (1-12d)		**B** **A**	**E** **B**	**A*** **A^{A}***	**A** **A^{A}**	**A** **A**	**B** **A**	Kang et al. 2013
80 (1- 5d)	*Ipomoea digitata*	Root : Ethan. Ext.	500	Concomitant (1- 5d)	**A**	**A^{A}**		**B***	**A**			Kalaiselvan et al. 2010
80 (1-10d)	*Lavandula officinalis*	Leaf: Etha. Ext.	100 200 400	Concomitant (1-10d) + Curative (11d)		**E** **E** **E**	**E** **E** **B**	**E*** **A^{A}*** **C***	**C** **B** **A**			Kalantar et al. 2016
100 (1-8d)	*Macrothe-lypteris oligophlebia*	Rhizome : Etha. Ext.	250 500	Concomitant (1-8d)		**C** **A**	**C** **B**	**A*** **A***	**D*** **A***	**A** **A**	**A** **A**	Wu et al. 2012
40 (1-13d)	*Mimosa pudica*	Root: Etha. Ext.	200 400 600	Concomitant (1-13d) + Curative (14-21d)		**E** **E** **E**	**E** **D** **B**	**C*** **A*** **A***	**A** **B** **C**	**B** **A** **A**		Geetha et al. 2015
			600	Curative (14-21d)		**E**	**D**	**C***	**A**	**A**		
100 (1-6d)	*Mucuna pruriens*	Seed: Aqua Ext.	200 400	Concomitant (1-6d)	**B** **A**	**C** **A**		**E** **E**	**C** **A**	**B** **A**	**B** **A**	Modi et al. 2008
80 (35-42d)	*Momordica dioica*	Leaf : Etha. Ext.	200 400	Preventive (1-34d) + Concomitant (35-42d)	E **D**	**E** **E**	**C** **A**		**C/A*** **C/A***	**E** **B**	**C** **A**	Manimala et al. 2015
40		Fruit	200 200		C **C**	**E** **E**		**A*** **D***	**C** **A**			Jain and Singhai 2010
50 +50 (8-12d)	*Moringa oleifera*	Leaf: Powder	10,000	Preventive (1-7d) + Concomitant (8-12d)		**B**	**A**	**A***	**B/A***	**A**	**A**	Elazab and El-Habashi 2015

100 (1-14d)	*Nelumbo nucifera*	Flower: Etha. Ext.	200	Concomitant (1-14d)	**A**	**E**		**C***		**A/B***		**A**	**A**	Saraswathi and Shoba 2015
			400		**A^A**	**C**		**B***		**A/A***		**A**	**A**	
80 (1-6d)	*Nigella sativa*	Seed Oil	0.2mL /kg	Concomitant (1-6d)	**B**	**C**		**A***		**A***			**A**	Yaman and Balikci 2010
			0.4 mL/kg		**A**	**A**		**A***		**A***			**A**	
100 (1-8d)		Seed : Hexane Ext.	5 mL /kg	Concomitant (9-15d)		**E**				**B**				Begum et al. 2006
100 (1-7d)	*Ocimum gratissimum*	Leaf : Aqua. Ext.	100	Curative (8-14d)	**A**	**E**				**A**				Ogundipe et al. 2016
			200		**A**	**D**				**A**				
			400		**A**	**D**				**A**				
70 (1-28d)	*Olea europaea*	Leaf : Etha. Ext.	20	Concomitant (1-28d)	**E**	**E**				**C***	**B***	**D**	**A**	Abd El-Rahman 2016
			40		**D**	**D**				**B***	**A***	**C**	**A**	
			80		**E**	**C**				**A***	**B***	**C**	**A**	
			160							**B***	**B***	**C**	**A**	
80 (1-7d)	*Oroxylum indicum*	Whole plant : Metha. + Dichloro methane Ext.	200	Concomitant (1-7d)	**E**		**E**			**E***	**B***	**B**	**A**	Mishra et al. 2014
80 (1-9d)	*Orthosiphon stamineus*	Metha. Ext.	100	Curative (10-19d)	**C**		**E**		**C**					Kannappan et al. 2010
			200		**A**		**A**		**A**					
			200	Preventive	**A**		**A**		**A**					
100 (1-10)	*Panax ginseng*	Root	200	Concomitant (1- 10d)	**C**		**C**		**A***	**C/A***			**B**	Karadeniz et al. 2008b
100 (1- 8d)	*Pedalium murex*	Fruit : Eth. Ext.	600	Concomitant (1- 8d)			**D**	**B**	**B**	**A**		**A**		Sreedevi et al. 2011
		Fruit : Aqua. Ext.					**A**	**A**	**A**	**A**		**A**		
100 (1-14d)	*Pistacia khinjuk*	Fruit : Eth. Ext	150	Concomitant (1-14d)			**E**	**E**	**B***	**A**				Ghaedi et al. 2014
			300				**E**	**D**	**A***	**A**				
			600				**A**	**A**	**A***	**A**				
80 (1-15d)	*Portulaca oleracea*	Whole plant: Aqua. Ext.	400	Concomitant (1-15d)	**A**		**A**	**A***	**B***	**A**		**A**	**A**	Mouhamed and Elshafeey 2011
80 (4-11d)	*Psidium guajava*	Leaf: Etha. Ext.	200	Preventive (1-3d) + Concomitant (4-11d)	**C**		**E**		**A**	**A**				Patel et al. 2012
			400		**A^A**		**A^A**		**A^A**	**A**				
80 (1-8d)	*Punica granatum*	Fruit : Ext.	150	Concomitant (1-8d)					**A^A** *					Primarizky et al. 2016

100 (1-6d)		Fruit : Aqua Ext.	100µL	Concomitant (1-6d)	**C**	**E**		**A***	**A**			Cekmen et al. 2013
100 (3-9d)		Flower: Hydro Ethan. Ext.	25	Preventive (1-2d) + Concomitant (3-9d)		**A**	**A**	**D***				Sadeghi et al. 2015
			50			**D**	**E**	**E***				
80 (5-10d)	*Rhazya stricta*	Leaf: Aqua ext.	250	Preventive (1-4d) + Concomitant (5-10d)	**E**	**E**			**C**		**C**	Ali 2002
			500		**E**	**E**			**A**		**A**	
			1000		**D**	**A**			**A**		**A**	
100 (1-15d)	*Rheum emodi*	Rhizome: Chloro. Ext.	100	Concomitant (1-15d)		**E**	**E**					Aslam et al. 2014
		Pet Ether Ext.	100			**E**	**E**					
		Chloro. Ext. fractions	50		**SBF***	**E**	**E**	**E**	**A**	**A**	**A**	
					SCF*	**D**	**E**	**E**	**A**	**A**	**C**	
					SH*	**E**	**D**	**E**	**A**	**E**	**A**	
					CHL*	**C**	**E**	**E**	**A**	**A**	**B**	
					RE*	**E**	**E**	**E**	**D**	**C**	**E**	
100 (1-8d)	*Sida rhomboidea*	Leaf: Aqua Ext.	200	Concomitant (1-8d)	**C**	**C**	**N**	**E**	**B**	**D**	**E**	Thounaojam et al. 2010
			400		**B**	**A**	**A**	**C**	**A**	**B**	**C**	
100 (1-8d)	*Sida cordifolia*	Root: Aqua Ext.	200	Concomitant (1-8d)	**E**	**E**	**E**			**A**	**B**	Makwana et al. 2012
			400		**E**	**E**	**C**			**A**	**A**	
100 (1-5d)	*Sesamum indicum*	Seed oil	0.5mL /kg	Concomitant (1-5d)		**A**	**A**	**A**				Hsu et al. 2011
80 (4-11d)	*Spathodea campanulate*	Bark: Eth. Ext.	250	Preventive (1-3d) Concomitant (4-11d)	**A**^{A}	**B**		**A**^{A}	**C**			Shanmukha et al. 2010
			500		**A**^{A}	**A**^{A}		**A**^{A}	**B**			
100 (1-8d)	*Solanum nigrum*	Aqua Ext.	100	Concomitant (1-8d)	**B**	**C**			**A**	**A**	**A**	Priya and Venkata-lakshmi 2011
100 (1-8d)	*Solanum xantho-carpum*	Fruit: Eth. Ext.	200	Concomitant (1-8d)	**A**	**A**	**A**	**A**	**C**	**C**	**C**	Hussain et al. 2012
			400		**D**	**C**	**B**	**C**	**A**^{A}	**E**	**A**^{A}	
100 (1-10d)	*Sonchus asper*	Whole plant: Meth. Ext.	100	Concomitant (1-10d)	**B**	**E**			**A**	**C**	**C**	Khan et al. 2011
			200		**B**	**C**			**A**	**B**	**A**	
40 (1-7d)	*Tephrosia purpurea*	Leaf : Eth. Ext.	200	Curative (7-16d)	**B**	**E**		**E***	**A**		**C**	Jain et al. 2013
				Concomitant (1-7d)	**C**	**E**		**C***	**C**		**A**	
80 (1-14d)	*Terminalia ivorensis*	Stem bark :Eth. Ext.	100	Concomitant (1-14d)	**C**	**E**		**B**	**C**	**B**	**B**	Ansah et al. 2016
			800		**A**	**C**		**A**	**B**	**A**	**A**	
			1000		**A**	**D**		**A**	**A**	**A**	**A**	
80 (1-15d)	*Terminalia bellerica*	Stem: Etha. Ext.	500	Concomitant (1-15d)	**D**	**A**	**C***	**C***	**B**	**B**	**B**	Fatima and Sultana 2016
		Aqua Ext.			**B**	**A**	**A***	**A***	**A**	**A**	**A**	
80 (1-8d)	*Sphaeranthus indicus*	Whole plant: Eth. Ext.	150	Curative (9-19d)		**E**	**E**		**A/A***	**A**	**A**	Mathew et al. 2009
			300			**A**	**E**		**A/A***	**A**	**A**^{A}	

80 (1-14d)	*Trachy-spermum ammi*	Seed: Aqua Ext.	300	Concomitant (1-14d)	A	A	A			A		Ishaq et al. 2015
			600		A^A	A	A^A			A		
400	*Trianthema portula-castrum*	Whole plant powder	1000	NA	B	A	A^*	C	C/A^*		C	Vallabi and Elango 2015
100 (1-8d)	*Trichosan-thes dioica*	Leaf: Meth. Ext.	200	Concomitant (1-8d)	E	E	C	E	C	C	C	Gupta et al. 2015
			400		C	C	B	A^A	A	B	B	
100 (1-8d)	*Trigonella foenum graceum*	Seed: Aqua Ext.	200	Concomitant (1-8d)	E	E		E^*	D	D		Kaur et al. 2016
			400		D	E		E^*	C	D		
			800		B	E		D^*	A	A		
100 (1-10d)	*Urtica dioica*	Leaf: Eth. Ext.	100	Concomitant (1-10d)	A	A		A^*	E			Salih 2015
80 (1-7d)	*Vitex negundo*	Root: Metha. + Dichloro methane Ext.	200	Concomitant (1-7d)	D	D		C^*	B^*	B	A	Mishra et al. 2014
80 (8-21d)	*Vitis vinifera*	Seed Ext.	150	Preventive (1-7d) + Concomitant (8-21d)	A	C		C^*	B /A^*			El- Ashmawy et al. 2006
100 (1-7d)	*Zingiber officinale*	Rhizome Powder	5% of diet	Curative (8-56d)	A	A	A^*		D^*	C	B	El-Ghany et al. 2012
100 (1-7d)		Rhizome: gingerol fraction	6.25	Concomitant (5-7d)	C	C	E	E^*	D		C	Rodrigues et al. 2014
			12.5		A	B	E	D^*	C		C	
			25	Curative (8-9d)	A^A	A	B	A^*	A		B	

Fractions of chloroform Ext.: SBF = NaHCO3 fraction, SCF = Na2CO3 fraction, SHF = Sodium hydrate fraction, CHL= solutes in left out chloroform layer, RE = ppt formed after adding NaHCO3 in chloroform Ext.

Table 5. Ameliorative role of plant species on biochemical markers of kidney health and oxidative stress at different time intervals.

GM (mg/Kg B. wt)	Plant	Herbal: Prep-ration	Herbal: Dose mg/kg B. wt	Herbal: Protocol	Day	Prognosis: Kidney functions: U	C	BUN/ UA*	LPO/ MDA*	Oxidative stress: GSH/ GPX*	CAT	SOD	References
150 (1-10d)	*Boerhavia diffusa*	Aqueous Ext. of whole plant	200	Concomitant (1-10d)	1d		A^A	A					Sawardekar and Patel 2015
					11d		A	A	B^*	A			
			400		1d		A^A	A					
					11d		D	B	A^*	A			
80 (1-8d)	*Hygro-phila spinosa*	Ethan. Ext. of whole plant	50	Curative (9-30d)	1d	A^A	A^A						Bibu et al. 2010
					9d	E	E						
					15d	D	E						
					30d	A^A	E		C	E	E	E	
			250		1d	A^A	A^A						
					9d	E	E						
					15d	A	A^A						
					30d	A^A	A^A		A^A	E	E	E	
80 (1-8d)	*Eclipta alba*	Leaf: Meth. Ext.	300	Concomitant (1-8d)	0d		A^A	A^A					Dungca 2016
					8d		A^A	C	A		A		
			600		0d		A^A	A					
					8d		A^A	C	A^A		C		
80 (1-9d)	*Verbas-cum thapsus*	Leaf: Meth. Ext.	250	Concomitant (1-9d)	1d	A	A	A					Pal et al. 2013
					3 d	C	A	C					
					5 d	A^A	A	C					
					9 d	D	A	D	D	E	C	C	
			500		1 d	A	A	A					
					3 d	B	A	B					
					5 d	B	A	B					
					9 d	C	A	A	E	C	B	A	

Seed: *Glycine max*, *Kalonchoe*, *Phyllanthus amarus*, *Sesamum*, *Mucuna, Cucumis sativus*

Fruit: *Rubus elliptus*, *Phoenix dactylifera*, *Pedalium*, *Pistacia*, *Solanum xanthocarpum*

Milk: *Cocos nucifera*

Whole plant: *Boerhavia*, *Orthosiphon*, *Portulaca*

Curcuma rhizome in combination with seeds of *Petroselinium* and *Eruca* improved kidney function to **good category**.

- **Moderate** protection/recovery in kidney functions was observed when plant parts of following plant species were administered to the gentamicin treated animals (Table 2-5).

Belowground organs

Root: *Andrographis*, *Daucus*

Rhizome: *Curcuma longa*, *Macrothelypteris, Nelumbo*

Aboveground organs

Leaf: *Aristolochia*, *Bauhinia variegata*, *Dalbergia*, *Eclipta, Houttuynia*, *Rosamarinus, Sida rhomboidea, Trema, Verbascum* and *Trianthema*

Shoot: *Bacopa*, *Terminalia bellerica, Terminalia ivorensis*

Seed: *Elettaria*, *Eruca*, *Lagenaria*, *Petroselium, Strychnos, Vitis vinifera*

Flower: *Nelumbo nucifera*, *Pongamia pinnata*

Fruit: *Bauhinia purpurea*, *Tamarindus indica*, *Morus alba*

Whole plant: *Trianthema*, *Phyllanthus niruri*

- The plant parts of following species belonged to **excellent category** for protection/recovery of oxidative stress and antioxidant levels (Table 4,5).

Leaf: *Houttuynia*, *Psidium*

Whole plant: *Sphaeranthus*

Fruit: *Punica*

- The plant parts of following plant species belonged to **good category** for protection/recovery of oxidative stress and antioxidant levels (Table 4, 5).

Belowground organs

Root: *Sida cordifolia*

Rhizome: *Curcuma longa*, *Macrothelypteris*

Corm: *Amorphillus*

Aboveground organs

Leaf: *Casuarina*, *Camellia sinensis*, *Cynara*, *Euclea*, *Graptophyllum*, *Ocimum gratissimum*, *Rhazya*

Shoot: *Bacopa*, *Terminalia bellerica*

Bark: *Alangium*, *Terminalia ivorensis*

Flower: *Calotropis*, *Cocos nucifera*

Fruit: *Pedalium*, *Pistacia*

Milk: *Cocos nucifera*

Seed: Punica, *Sesamum*, *Nigella*, *Trachyspermum*

Whole plant: *Boerhavia, Orthosiphon*

Combination: *Curcuma* (rhizome) + *Petroselinium* (seed) + *Eruca* (seed)

Foeniculum (seed) + *Solanum nigrum* (fruit)

- The plant parts of following plant species belonged to **moderate category** for protection/recovery of oxidative stress and antioxidant levels (Table 4, 5).

Belowground organs

Root: *Vitex*, *Glycyrrhiza*, *Ipomea digitata, Mimosa pudica, Panax*

Aboveground organs

Leaf: *Aegle*, *Aristolochia, Eclipta, Lavandula, Momordica dioica, Moringa, Olea, Sida rhomboidea, Tephrosia, Trichosanthes*

Bark: *Ficus racemosa, Spathodea*

Flower: *Cocos, Momordica dioica, Nelumbo*

Seed: *Eruca*, *Elaeocarpus*, *Foeniculum*, *Petroselinum*, *Glycine*, *Vitis*

Whole plant: *Portulaca, Ferulago, Sonchus, Trianthema*

Punarnava (*Boerhaavia diffusa*), Gokshur (*Tribulus terrestris*), Haritaki (*Terminalia chebula*), Neem (*Azadirachta indica*), Daruharidra (*Berberis aristata*) and Patol (*Tricosanthes dioica*) are some of the species used in treating kidney disorders in the Ayurvedic treatment. Bilvadi agada is an ayurvedic drug having nephroprotective role in gentamicin exposed Wistar rats (Kanna et al.2015). It is mixture of *Aegle marmelos, Ocimum sanctum, Pongamia pinnata, Valeriana wallichi, Cedrus deodara, Phyllanthus emblica, Terminalia chebula and Terminalia bellirica, Zinziber officinale, Piper nigrum, Piper longum, Curcuma longa, Berberis aristata* and *goat's urine*.

Interestingly, *Aegle marmelos* (Moderate), *Boerhaavia diffusa* (Excellent), *Curcuma longa* (Moderate), *Ocimum sanctum* (Good), *Pongamia pinnata* (Moderate), *Tribulus terrestris* (Moderate), *Terminalia chebula* (Excellent), *Terminalia bellirica* (Moderate), *Tricosanthes dioica* (Moderate) and *Zinziber officinale* (Moderate) were also found renoprotective in the experimental studies (Table 2,4).

Out of 142 species (angiosperms) screened in the gentamicin treated animals, majority (105 species) were effective (moderate – excellent) for renoprotection and reducing oxidative stress. Many of them are used in preparing renoprotective drugs in the Ayurvedic system. Plant species of excellent category may be explored for ameliorative role to other nephrotoxicants singly as well as in various combinations. The recommended dose of gentamicin for human is 20µg/kg body weight while several plant species were excellent in term of protection to experimental animals even at its higher doses (80-100mg/kg body weight), and therefore, there is a good scope for their clinical trials in the human beings treated with gentamicin.

Presence of renoprotective properties among such a vast number of species highlights role of biodiversity in the welfare of mankind. *Cuscuta* considered as an obnoxious stem parasite is a very interesting example that nature blesses to the mankind because of its excellent renoprotective properties. Several of renoprotective species are cultivated for human consumption while others grow wild on wastelands, farmlands and forests. Interestingly many of them are used daily in the preparation of the Indian cuisines.

Interestingly few of the most promising renoprotective plant species grow luxuriantly on wastelands, farmlands and forests in the Rajasthan. Thirty two plant species growing wild or naturalised in the State of Rajasthan have been screened for their reno-protective role. These are; *Abutilon indicum*, *Acacia senegal, Adhatoda zeylanica*, *Aegle marmelos*, *Aloe barbadensis*, *Bacopa monniera*, *Bauhinia purpurea* ,*Bauhinia variegate*, *Boerhavia diffusa*, *Boswellia serrata*, *Calotropis procera*, *Citrullus colocynthis, Cuscuta reflexa*, *Dalbergia sissoo*, *Eclipta alba, Gomphrena celosioides*, *Ipomoea aquatica*, *Nelumbo nucifera*, *Pedalium murex*, *Phyllanthus niruri*, *Portulaca oleracea, Sida cordifolia*, *Solanum nigrum*, *Solanum xanthocarpum*, *Sonchus asper*, *Tamarindus indica, Terminalia bellerica*, *Terminalia chebula*, *Trianthema portulacastrum*, *Tribulus terrestris*, *Vitex negundo and Withania somnifera*. Out of these 32 species, 3 species were excellent (*Acacia senegal, Cuscuta reflexa, Eclipta alba*) while others were good to moderate for renoprotection. Natural calamities such as drought, diseases (microbial and viral) and insect damages affect their growth little since these have evolved through natural selection. Their cultivation may be promoted on wastelands and farmlands in the rural areas to prosper sustainable development since these are less demanding in comparison to conventional crops. Various government organizations should come forward in developing technology for cultivation of elite renoprotective species, network for their collection and storage practice after harvest and linkage with Pharma industry. Such interventions will benefit farmers particularly those enganged in subsistence farming while country will be benifitted by their export because of increasing demand for herbal drugs globally.

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