Potential Nutritional and Medicinal Sources from Fruit Peels in Manila, Philippines

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***Abstract*—The environment is continually deteriorating. Biodegradable wastes increase with increasing population. The problem in wastes affect the integrity of the earth. Problems in health and nutrition are common. Finding important chemicals from fruit peels like total sugars or carbohydrates, as well as alkaloids will help address daily challenges in nutrition and health. This study aimed to determine the phytochemicals present in the peels of the selected fruits obtained from Manila, Philippines. Specifically it aimed to determine the presence of total sugars and alkaloids. Further it aimed to obtain the amounts of total sugars and alkaloids in the fruit peel samples analyzed. All fruit peels from rambutan (*Nepheleum lappacium*), lanzones (*Lansium domesticum*), pomelo (*Citrus grandis*), longgan (*Dimocarpus longana*), dalandan (*Citrus nobilis*), ponkan (Citrus reticulata), mangosteen (*Garcinia mangostana*) qualitatively showed the presence of reducing sugars as well as glycosides. Pomelo, rambutan, longgan, and mangosteen contain tannins. Lanzones contains alkaloids. Sugars and alkaloids for lanzones gave the highest intensity in the phytochemical screening done. It was only lanzones which gave positive results to all tests related to alkaloids. The amounts of total sugars in both the diluted and stock solution (20% decoction) fruit peel samples showed a range of 1.801 to more than 164 ug/ml concentrations. The alkaloidal contents of lanzones showed 0.0312 mg/ml level at 1:9 dilution. Since the samples studied showed the presence of heavy metals, although still within the allowed limit by USP and NF, it is best to decontaminate the fruit peels or isolate and purify the active ingredient/s from it prior to the actual preparation of the pharmacologic and nutritional products.**

***Index Terms*—Fruit peels, medicinal preparations, nutritional supplements, Philippines**

I. Introduction

A. Background

Human and animal wastes are biodegradable. Kitchen wastes make up the bulk of household wastes. Crop residues and animal manure are now being used to build up organic matter in the soil. Such practice supports sustainability as it replenishes nutrients by recycling all elements [1]. By looking at the phytochemistry of wastes like fruit peels, possible nutritional and medicinal substances may be discovered.

Carbohydrates, contain sugars and are integral parts of nutrition. It was shown in a study that compared with the higher-income food-sufficient households, children in the low-income food-insufficient households consumed fewer calories and total carbohydrates, but had a higher cholesterol intake making them more overweight [2] Carbohydrates are aldehyde and ketone alcohols containing carbon, hydrogen and oxygen in which the hydrogen and oxygen are in generally the same ratio as in water. It may be classified into two broad groups: sugars and polysaccharides. Sugars are monosaccharides, ie., compounds that cannot be hydrolyzed to simple sugars; disaccharides which yield two monosaccharide molecules on hydrolysis; trisaccharides which yield three; tetrasaccharides, which yield 4; and so on. Polysaccharides on the other hand can usually be hydrolyzed to a component hexose and are therefore called hexosans;starch, which yield glucose is known as glucosan; and inulin, which yields fructose, is known as fructosan. Sugars and starch are important products in the economy of mankind. They are extensively used as foods and pharmaceuticals [3]. Lately, even livestock are monitored especially of this nutrient. Other substances considered are protein, calcium, vitamin A, Vitamin B complex and zinc [4].

Alkaloids are extremely difficult to define because they do not represent a homogeneous group of compounds from either the chemical, biochemical or physiologic viewpoint. Consequently except for the fact that they are all organic nitrogenous compounds, reservations must be appended to any general definition. Most possess basic properties, owing to the presence of an amino nitrogen and many, especially those pertinent to pharmacy and medicine possess marked physiologic activity [3]. Alkaloids may be present in fruit peels. In one research β-carboline alkaloids are of great interest due to their diverse biological activities. It is said to intercalate into DNA,inhibit CDK, Topisomerase, and monoamine oxidase, and to interact with benzodiazepine receptors and 5-hydroxy serotonin receptors. It has also demonstrated sedative, anxiolytic, hypnotic, anticonvulsant, antitumor, antiviral, antiparasitic as well as antimicrobial activities which are important pharmacologic discoveries [5]. *Carica papaya* seed extract may be used for pharmaceutical drug development as a male contraceptive. It prevented ovum fertilization, reduced sperm cell counts, caused sperm cell degeneration, and cell lesion in the testicles. This is due to the observed presence of alkaloids in papaya [6].The alkaloids dauricine and daurisoloine have been isolated from *Menispermum dauricum* DC. Dauricine showed an antiarrhythmic effects [7]. Potatoes contain glycoalkaloids and polyphenols which may be used as antioxidants and precursors for steroid hormones. It is also essential for its fiber contribution [8]

The result of this study will find better use of fruit peels. Pharmacologic preparations may be developed and nutritional substances discovered. Local government units will be able to plan for better recycling of kitchen wastes particularly, fruit peels.

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B. Objectives

This study in general aimed to determine the phytochemicals present in the peels of the selected fruits obtained from Manila, Philippines. Specifically it aimed to determine the presence of total sugars and alkaloids. Further it aimed to obtain the amounts of total sugars and alkaloids in the fruit peel samples analyzed.

C. Scope and limitation

The research used only seven sample fruit peels namely rambutan (*Nepheleum lappacium*), lanzones *(Lansium domesticum*), pomelo (*Citrus grandis*), longgan (*Dimocarpus longana*), dalandan *(Citrus nobilis*), ponkan *(Citrus reticulata*), mangosteen *(Garcinia mangostana*). It determined the different phyto chemicals using qualitative chemical tests. Spectrophotometry was used to determine the quantitites of alkaloids and total sugars in the samples analyzed.

II. Methodology

A. Research Design

This study made use of the descriptive, exploratory design. Both qualitative and quantitative tests were used to describe the unknown components of the fruit peel samples analyzed.

B. Locale of the Study

The fruit peels were gathered from Manila, Philippines. The samples were stored, prepared and analyzed at the University of the Philippines, Manila

C. Sample Collection

The fruit peels were gathered from vendors in Manila, Philippines. These were placed in separate brown bags and stored inside the refrigerator overnight.

D. Sample Preparation.

The peels were separated from the peels. The peels were washed with running water for ten minutes, damped with a clean cloth, air dried and comminuted. Twenty percent aqueous and thirty percent ethanolic extracts were used for the phytochemical tests. The samples were prepared for spectrophotometric analysis according to the procedure followed.

E. Phytochemical Screening

The acidity and different components tannins, glycosides, reducing substances, alkaloids, plant acids, saponins, proteins, mucins, flavonoids,of the test sample were analyzed following the phytochemical tests from the Plant Chemistry Manual of the Department of Pharmaceutical Chemistry Faculty, 2008 [9].

F. Quantitative Determination of Alkaloids

Preparation of solutions Bromocresol green solution ($1X10^{-4}$) were prepared by heating 69.8 mg bromocresol green with 3 ml of 2N NaOH and 5 ml distilled water until completely dissolved and the solution was diluted to 1000 ml with distilled water. Phosphate buffer solution (pH 4.7) was prepared by adjusting the pH of 2 M sodium phosphate (71.6 g Na_2HPO_4in 1 L distilled water) to 4.7 with 0.2 M citric acid (42.02 g citric acid in 1 L distilled water).Atropine standard solution was made by dissolving 1mg pure atropine (Sigma Chemical, USA) in 10 ml distilled water. For the standard curve, aliquots (0.4, 0.6, 0.8, 1 and 1.2 ml)of atropine standard solution were accurately measured and transfered each to different separatory funnels. Then, 5 ml pH 4.7 phosphate buffer and 5 ml BCG solution were added and shaken with 1, 2, 3 and 4 ml of chloroform. The extracts were collected in a 10-ml volumetric flask and then diluted to adjust volume with chloroform. The absorbance of the complex in chloroform were measured at 470 nm against blank prepared as above but without atropine.The plant materials (100g) were ground and extracted with methanol for 24 h in a continuous extraction (soxhlet) apparatus. The extracts were filtered and methanol was evaporated on a rotary evaporator under vacuum at a temperature of 45 C to dryness. The residue was dissolved in 2 N HCl and then filtered. One ml of this solution was transferred to a separatory funnel and washed with 10 ml chloroform (3 times). The pH of this solution was adjusted to neutral with 0.1 N NaOH. Then 5 ml of BCG solution and 5 ml of phosphate buffer was added to this solution. The mixture was shaken and the complex formed will be extracted with 1, 2, 3, and 4 ml chloroform by vigorous shaking. The extracts were collected in a 10-ml volumetric flask and diluted to volume with chloroform.. The absorbance of the complex in chloroform was measured at 470 nm [10].

G. Quantitative Determination of Total Sugars

Anthrone at 0.2% was prepared with sulfuric acid as solvent. Glucose solution at 100ug/ml was prepared. A range of serial dilution for glucose solution was made (10-100ug/ml) in a volume of 1 ml each. A blank of distilled water of 1 ml was also prepared. To each tube, 4 ml of anthrone was added, mixed and covered with glass marbles. These were incubated in boiling water bath for 10 minutes. Cooled to room temperature and absorbance were measured at 620nm after setting to zero absorbance (100% transmittance using the blank).The standard curve was drawn. The same procedure was employed for the20% decoction fruit peel samples [11].

III. Results and Discussion

Based on the phytochemical screening conducted, all fruit peels qualitatively showed the presence of reducing sugars as well as glycosides. Pomelo, rambutan, longgan, and mangosteen contain tannins. Lanzones contains alkaloids (Tables I and II). Sugars and alkaloids in lanzones showed high intensity with the qualitative tests used. Only lanzones yielded positive results to all tests related to alkaloids

TABLE I: PHYTOCHEMICAL SCREENING OF MANGOSTEEN, PONKAN, DALANDAN AND LANZONES.

	Mangosteen	Ponkan	Dalandan	Lanzones
pH	5	4	4	6
Tannins	Blue-black ppt	Yellowish brown solution	Black solution	Black solution
Glycosides	Blue green fine ppt	Cream to brown fine ppt	White fine ppt	White fine ppt
Reducing substances	Brick red ppt	Brick red ppt	Brick red ppt	Brick red ppt
Alkaloids Mayer's Valser's Wagner's Dragendorff's	 Cherry red soln Cherry red soln Cherry red soln Cherry red soln	 Brownish yellow soln Brownish yellow soln, fine cream ppt Brownish red soln Red orange soln	 Brownish yellow soln Brownish yellow soln Brownish red soln Orange solution	 Brown yellow soln brown ppt Brown yellow soln red ppt Red brown soln brown ppt Reddish orange solnbrown ppt
Plant acids	Brownish black solution;no stable and dense froth	Light brown solution; no stable and dense froth	Light brown solution; no stable and dense froth	Light brown solution; no stable and dense froth
Saponins	No froth; <1cm temporary on standing	No froth; <1cm temporary on standing	No froth; <1cm temporary on standing	No froth; <1cm temporary on standing
Liebermann Burchard	Dark red solution with red ppt	Bloody red to black solution	Greenish black to black solution	Brown turbid solution to brownish black solution
Salkowski	Bloody red to two layers (upper-black turbid, lower-yellowish clear solution)	yellow to blood red solution to two layers (upper- clear black , lower-dark red solution)	yellow to blood red solution to two layers (upper-clear reddish brown, lower- black solution)	Red to blood red solution to two layers (upper-clear reddish brown, lower-dark red solutionz)
Satd alcoholic solution of cholesteol	Amber solution	Light orange solution with crystal white formations	Brownish yellow solution	Brown solution with brown ppt
Flavonoids Standard 2N HCl in 1 propanol	Black soln,white gelatinous ppt Red coloration	Brownish black solution with fine white ppt Yellowish orange solution	Black solution with fine white ppt Brown solution	Brown solution with brown ppt Yellow orange solution

TABLE II: PHYTOCHEMICAL SCREENING OF POMELO, LONGGAN AND RAMBUTAN.

	Pomelo	Longgan	Rambutan
pH	4	4	3
Tannins	Blackish brown ppt	Blackish brown ppt	Blackish brown ppt
Glycosides	White fine ppt	White fine ppt	White fine ppt
Reducing substances	Brick red ppt	Brick red ppt	Brick red ppt
Alkaloids- Mayer's Valser's Wagner's Dragendorff's	Light yellow solution Yellow solution,fine brown ppt Red solution, very fine black ppt Yellow orange solution	Yellow solution Yellow orange solution Red soln,very fine black ppt Yellow orange solution	Yellow orange solution Yellow orange solution Red soln very fine black ppt Yellow orange solution
Plant acids	Yellow solution; no stable and dense froth	Amber solution; no stable and dense froth	Brownish yellow solution; no stable and dense froth
Liebermann Burchard	Brown solution to two layers (upper-yellowish clear , lower-red turbid solution)	Brown color to two layers (upper-dark brown, lower- dark red solution	Yellowish to two layers (upper-clear colorless, lower-light brown solution
Salkowski	Brown solution to two layers (Upper- clear colorless, lower- amber solution)	Brown solution to three layers (top-clear brown, middle-dark red, bottom- clear light yellow solution)	Yellowish solution to two layers (clear colorless, lower- yellow solution)
Saturated alcoholic solution of cholesteol	Yellow solution with very fine white ppt	Yellow solution with very fine white ppt	Brownish yellow solution with very fine white ppt
Flavonoids Standard 2N HCl in 1 propanol	Brownish yellow solution Yellow solution	Lime green solution Yellowish red solution	Blackish brown solution Yellowish red solution

Using spectroscopy, it showed that all seven tested peel samples namely, rambutan (*Nepheleum lappacium*), lanzones (*Lansium domesticum*), pomelo (*Citrus grandis*), longgan (*Dimocarpus longana*), dalandan (*Citrus nobilis*), ponkan (*Citrus reticulata*), mangosteen (*Garcinia mangostana*) contain carbohydrates from a 1:99 dilution of the stock solution until the actual stock solution concentration (20% decoction). The standard curve gave a slope b equal to 0.01752, and y intercept(a) equal to 1.7154 and an r of 0.9339. In general, the amounts of sugars are relatively high in all seven samples. Most readings went beyond 164 ug/ml starting with the 1:9 dilution until the actual stock solution concentration (Table III). It is expected then that increasing the decoction percentage (more than 20% decoction) will likewise increase the amount of sugars.

From the prepared decoction of the fruit peels used, a range of concentrations were noted. The lowest value of total sugars was seen from lanzones peels at 1.801 ug/mL with the dilution of 1:99 or a concentration of 0.1801 mg/mL. The highest amount of total sugars was at more than 164 ug/ml coming from ponkan, dalandan, pomelo, longgan at dilution!: 9 or a concentration of 1.64 mg/mL. With the recommended daily allowance of carbohydrates for children at 130 g/day [12], nutritional deficit with the said substance should not happen then even in low-income families since even fruit peels contain it. The preparation of higher fruit peel decoction concentrations for cooking, drinking and incorporation of whole fruit peels in other food preparations as additives to cakes, breads, cookies, juices or cocktails will increase its carbohydrate utilization. The peels however must be free of other chemical contaminants prior to use.

With the standard curve for atropine having a slope b equal to 1.25179, and a y intercept (a) equal to 0.05817 and r equivalent to 0.9728, the amount of alkaloids in lanzones was determined. A 0.0312 mg/ml alkaloid content was measured from lanzones. As the dilution factor used was 10, from 20g/20ml source of the fruit peel, 0.312 mg/ml alkaloid was obtained. Potential medicinal products may be obtained from fruit peels since it contain alkaloids even as it was diluted from the primary source with hydrochloric acid. Fruit peels accumulate daily in kilograms and in tons every month. Finding alternative uses for it in relation to nutrition and medicine is best.

Although the qualitative tests showed greatest intensity for total sugars for all seven samples and alkaloids in lanzones, glycosides and tannins were also observed in all fruit peel samples analyzed. Glycosides are compounds that yield one or more sugars as products of hydrolysis. Glycosides contribute to almost every therapeutic class in medicine. Some of the most valuable cardiac specifics are glycosides from digitalis, strophanthus, squill, convallaria, and apocynum among others.Laxative drugs like senna, aloe, rhubarb, cascara sagrada and frangula contain emodin and other anthraquinone glycosides. From black mustard, sinigrin yields allyl isothoicyanate, a powerful local irritant. Gaultherin from wintergreen yields methyl salicylate which is an analgesic. Tannins usually occur as mixtures of polyphenols. Tannins precipitate proteinsfrom solution and can combine with proteins rendering them resistant to proteolytic enzymes. Tannins then are used as astringents on gastrointestinal tract and skin abrasions.It is also used in the process of vegetable tanning which converts animal hide to leather. Tannins are also used as antidote for alkaloidal poisoning. It inactivates the alkaloid by forming tannates [3].

Varied fruit peels from Manila, Philippines contain heavy metals like cadmium and chromium, which includes the samples analyzed in this research (Table IV) [13]. Though the amounts of the heavy metals identified did not go beyond the allowed limit for pharmaceutical preparations at 10ppm, it is still best to decontaminate the fruit peels prior to formulation of nutritional supplements or medicinal products. Tahong (*Perna viridis*) has the ability to remove heavy metals, lead and cadmium, from water sources [14]. As such it can remove the contaminants in the fruit peel decoction studied. It is also best to isolate and purify the active phytochemicals from rambutan (Nepheleum lappacium), lanzones (*Lansium domesticum*), pomelo (*Citrus grandis*), longgan (*Dimocarpus longana*), dalandan (Citrus nobilis), ponkan (*Citrus reticulata*), mangosteen (*Garcinia mangostana*) to avoid unwanted chemical contaminants and at the same time improve the potency of the preparations.

TABLE III: CONCENTRATION OF TOTAL SUGARS IN SELECTED FRUIT PEELS.

Concentration of total sugars (ug/mL)							
	Mangosteen	**Ponkan**	**Dalandan**	**Lanzones**	**Pomelo**	**Longgan**	**Rambutan**
Stock solution*	>164	>164	>164	>164	>164	>164	>164
1:1	>164	>164	>164	145.1	>164	>164	>164
1:4	>164	>164	>164	110.05	>164	>164	>164
1:9	139.25	>164	>164	39.4	>164	>164	93.65
1:99	8.4	26.95	2.45	1.801	22.5	37.75	12.75

TABLE IV: CADMIUM AND CHROMIUM FROM SELECTED FRUIT PEELS IN MANILA, PHILIPPINES.

	Cadmium		Chromium	
Fruits	Peels	Flesh	Peels	Flesh
longgan	0.001+/-0.0021	0.0101+/-0.0014	0.0001+/-0.0012	0.0002+/-0.0012
lanzones	0.002+/-0.0014	0.0098+/-0.0006	0.0001+/-0.0012	0.0002+/-0.0005
mangosteen	0.0026+/-0.0023	0.003+/-0.0005	0.0011+/-0.0003	0.0013+/-0.0006
rambutan	0.0054+/-0.0007	0.0067+/-0.0006	0.0002+/-0.0005	0.0011+/-0.0008
ponkan	0.0041+/-0.0004	0.005+/-0.0009	0.1143+/-0.0011	0.3613+/-0.0006
dalandan	0.0023+/-0.0003	0.0032+/-0.0006	0.1284+/-0.0005	0.206+/-0.0008

Heavy metals like cadmium and chromium may result to unwanted effects to the human body. Cadmium may cause severe arthralgia and osteomalacia in middle aged postmenopausal women with low calcium and vitamin D intake, or itai-itai disease. It attacks the kidneys on chronic poisoning, lungs and gastrointestinal tract on acute inhalation and ingestion, respectively around 25%is absorbed by inhalation, and 5% through ingestion. It is not well absorbed through the skin at 0.5% [13].

The toxic potential of chromium depends on its oxidation state. Chromium (VI) is more toxic than chromium (III). Ingestion of high amounts of chromium (VI) causes adverse gastrointestinal effects in humans and animals. It causes unwanted affects to the respiratory, hepatic, endocrine, immunological, and neurologic system. Accumulation of chromium can lead to cancer. It can adversely affect the gastrointestinal tract upon ingestion [13].

It is because of the reasons stated that heavy metals must be removed from the sample peel wastes before preparing nutritional supplements and medicinal products from it. As this study intended to provide better health conditions to the Filipino people, it was not just by offering novel potential formulations that was considered but also decontamination of or isolation and purification of the active ingredient/s from the fruit peel sources.

IV. CONCLUSIONS

All fruit peels qualitatively showed the presence of reducing sugars as well as glycosides. Pomelo, rambutan,

longgan, and mangosteen contains tannins. Lanzones contains alkaloids. Carbohydrates (sugars) and alkaloids for lanzones gave the highest intensity in the phytochemical screening done. It was only lanzones which gave positive results to all tests related to alkaloids. The amounts of total sugars in both the diluted and actual stock solution concentration ranged from 1.801 to more than 164 ug/ml concentrations. With dilution factor of 10, more than 1.64 mg/ml total sugar was obtained using 20% decoction as stock solution of the selected fruit peel samples. The alkaloidal contents of lanzones showed 0.0312 mg/ml level at 1:9 dilution. Since the dilution factor used was 10, from 20g/20ml source of the fruit peel, 0.312 mg/ml was obtained. Fruit peels have essential chemicals that are important for the production of nutritional supplement and medicinal formulations. However, since the samples studied showed the presence of heavy metals, it is best to decontaminate the fruit peels or isolate and purify the active ingredient from it prior to the actual preparation of the nutritional and medicinal products.

V. Recommendations

Though it was established using qualitative and quantitative chemical tests that the selected fruit peels contain total sugars, further analysis must be done to determine the exact amount of sugars in peels that exceeded the absorbance limit of 5.00 with concentration of 164 ug/ml. Elucidation of the varied sugars and alkaloids present in all fruit peels and lanzones peels respectively is highly recommended. Isolation, and purification of the alkaloids in Lanzones peels is suggested in preparation for medicinal and other related formulations. Decontamination of fruit peels before preparaing nutritional and medicinal products must be performed.

References

[1] B. Nebel and R. Wright. *Environmental Science*. New Jersey, USA: Prentice Hall, 2000.

[2] P. Casey, K. Szeto, S. Lansing, M. Bogle, and J. Weber. "Children in food-insufficient," *Low-Income Families Arch Pediatr Adolesc Med.* 2001, vol. 155, pp. 508-514.

[3] V. Tyler, L. Brady, and J. Robbers *Pharmacognosy* 8th edn. Philadelphia: Lea and Febiger, 1981.

[4] S. Ehui, H. Li-Pun, V. Mares, and B. Shapiro. "The role of livestock in food security and environmental protection," *Outlook on Agriculture* vol. 27, no. 2,1998, pp. 81-87

[5] R. Cao, W. Peng, Z. Wang, and A. Xu, "β-carboline alkaloids: biochemical and pharmacological functions," *Current Medicinal Chemistry*, vol. 14, no. 4, February 2007, pp. 479-500

[6] F. V. Udoh, P. B. Udoh, and E. E. Umoh "Activity of alkaloid extract of *Carica papaya*, Seeds on Reproductive Functions in Male Wistar Rats," *Pharmaceutical Biology*. vol. 43, no. 6, 2005, pp. 563-567.

[7] J. Qian, "Cardiovascular pharmacological effects of bisbenzyl-isoquinoline alkaloid derivatives," *Acta Pharmacol Sin* Dec 2002, vol. 23, no. 12, pp. 1086-1092.

[8] A. Scheiber and A. M. Saldana, "Potato peels: A source of nutritionally and pharmacologically interesting compounds," *Food* vol. 3 no. 2, pp. 23- 29, 2009.

[9] "Department of pharmaceutical chemistry faculty," *Laboratory Manual in Plant Chemistry*. UP Manila, 2008.

[10] F. Shamsa, H. Monsef, R. Ghamooshi, and M. Verdianrizi, "Spectrophotometric determination of total alkaloids in some Iranian medicinal plants," *Thai J. Pharm.* Sci. vol. 32, no. 19, pp. 17-20, 2008

[11] A. Nigam and A. Ayyagar, "Laboratory manual in biochemistry," *Immunology and Biotechnology*. New Delhi: Tata Mc Graw Hill Publishing Co limited, 2007.

[12] Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Proteins and Amino Acids (Macronutrients). The National Academies Press, 2005. [Online]. Available: http://www.nap.edu/openbook.php? record_ id= 10490&page=285

[13] J. N. Solidum, "Cadmium and chromium levels in sselected fruit peels from manila philippines," In *Proceedings International Conference of Chemical and Biological Processes*. Kuala Lumpur, Malaysia, June 21-24, 2012.

[14] J. N. Solidum and G. G. Solidum, "Assessment and remediation of heavy metals in community tap water from manila philippines," In *International Proceedings of Chemical, Biological and Environmental Engineering*, IACSIT Press, Singapore, vol. 32, April 2012