"The Egyptian waterhyacinth offset paper strength properties & printability parameters evaluation."

By: Dr. Ahmed Mahmoud Yosri Ahmed
Associate Professor/ Faculty of Applied Arts \\
Printing, Publishing & Packaging Sector \\
Helwan University \\ Cairo\\ Egypt.
ahmedyosri1@hotmail.com

Introduction:

Historically, the first appearance of waterhyacinths was on South America Rivers. Water-hyacinths are known of their broad, thick, glossy and ovate leaves.

The waterhyacinths rise above the surface of fresh water rivers as much as 1 meter in height. The leaves are 10-20 cm across, and float above the water surface. The waterhyacinths have long, spongy and bulbous stalks. The feathery, freely hanging roots are purplish black.

Image "1": The waterhyacinth plant.

An erect stalk supports a single spike of 8-15 conspicuously attractive flowers ,mostly lavender to pinkish in color with six petals.

Image "2": The waterhyacinth flower.

The waterhyacinth is one of the fastest growing plants ever known, it can double its population in two weeks. It also produces large quantities of seeds, and these are viable up to thirty years!

As an industrial usage and since the waterhyacinths have abundant nitrogen content, they can be used as a substrate for biogas production and the sludge obtained from the biogas. However, due to easy accumulation of toxins, the plant is prone to get contaminated when used as feed.

The waterhyacinth is extremely tolerant towards, and of high capacity of up taking heavy metals, such as Cd, Cr, Co, Ni, Pb and Hg etc, so it could be utilized for the bio-cleaning of industrial wastewater & mining operations wastes.

In my research here, I'm trying to detect the quality of the offset paper made of the Egyptian water- hyacinths' stalks.

Research importance:

The waterhyacinth causes many problems in the River Nile basin countries, containing Egypt. The waterhyacinths consume massive amounts of drinking water for agriculture, and impede the movement of navigation, irrigation and clog waterways. They also consume the oxygen dissolved in water, which threatens the lives of fish and aquatic organisms. In addition, water-hyacinths house many of the snails and snakes. It was calculated that; 1 kilogram of waterhyacinths exhausts 4 liters of fresh water, daily!

Image "3": The waterhyacinths impede the movement of navigation & completely clog waterways.

On the fourth of March 2011 the **Egyptian environment minister** has announced that, the affected Egyptian areas by waterhyacinths are about 638 square kilometers at that date. And the fresh water quantity consumed yearly by the waterhyacinth evaporation is 5.3 billion square meters. This wasted quantity is enough to irrigate about 450 square kilometers of agricultural land.

The Egyptian minister also has pointed out that the waterhyacinths-stiffness costs Egypt a fortune estimated at 150 million pounds every year.

As the biological control of waterhyacinths is costly and takes years of time, so this research offers using the waterhyacinths stalks as a local paper pulp source in Egypt and as a magic solution of all those ex-mentioned problems which harm seriously the Egyptian environment & economy.

Research target:

Evaluation the physical strength properties and the printability parameters of the Egyptian waterhyacinths' stalks lab made offset paper sheets against the European imported WoodFree (chemical cocked pulp) Uncoated offset \ WFU sheets.

Definitions:

- Paper basic physical properties: Basis weight, thickness, apparent density, bulk & kappa number (cellulose content).

- Paper common physical strength properties: Folding strength, tensile strength, tear strength, burst strength & perforation strength.

- Paper optical properties: CIE $l^*a^*b^*$color, whiteness (lightness), gloss, ISO brightness, opacity & Y value.

- Paper printability: it's the controller of the paper sheet "or web" performance on any analogue "or digital" printer "or copier". Also, it's the controller of the final out-putting printing "or copying" quality.

Paper printablity is a result of thousands reactions between the whole physical & optical paper properties, and hundreds of production variables on the printer "or the copier" the less sensitive the paper is under un-standardized printing "or copying" variables, the higher its printability is.

- Printablitiy tests: classified into two groups; virtual printing tests, carried on the same printer or copier assumed to be used for the mass production. And, the Lab tests group; achieved completely manually, or on the printability testers "e.g. IGT tester, Prufbau tester, RNA tester, Winstones tester & GATE tester".

- Printability parameters: divided into two groups; **solid** paper printability parameters, which are: ink requirement "the needed ink coverage", color values, print through, ink gloss, gloss contrast, unevenness and others.

The second group is the **halftone** paper printability parameters, which includes also the majority of the solid parameters plus; halftone reproduction curve & halftone dot properties.

- Ink requirement: the needed ink amount "g/m^2" on the paper surface, for obtaining a targeted certain ink density divided by that density value itself.

-Solid unevenness "noise or mottling" average: the sum of the absolute values of all the solid densities "or optical gloss degrees" variations, on a scale of 1 mm to 1 cm, divided by their number.

Research methodology:

A laboratory, experimental comparative methodology had been applied in the research here.

Apparatuses:

- 100 h.p. paper fibers miller.
- Experimental chemical fibers digester.
- TAPPI T200 confirmed laboratory paper fiber electrical beater
- 100 mesh manual laboratory paper making fibers presser.
- Folding endurance tester.
- Tear strength tester / 4 samples method.
- Burst strength tester.
- Hybrid digital tensile strength (elongation method) & perforation resistance tester.
- Digital spectrophotometer (to measure the samples lightness\ CIE-L^* profiles).
- Digital glossmeter.
- Digital densitometer.
- IGT 2 rolls printability tester.

Samples:

For the basic physical & strength physical properties measurement tests: tens of the lab made Egyptian waterhyacinths' stalks uncoated offset paper samples had been consumed, with a similar number of the imported WFU sold in the Egyptian markets samples.

For the solid printability parameters evaluation measurements: 5 samples (30 × 250 mm^2) of the lab made Egyptian waterhyacinths' stalks uncoated offset paper against other 5 samples of the imported WFU had been printed and measured.

The final printed area size on each sample was (20 × 200 mm^2). All the samples printed with a standard Egyptian black Bright (TM) lithoffset ink, manufactured by PACHIN paints & chemical industries co.

Testing circumstances & parameters:

Temperature = "22:24" ^{o}c. Humidity ratio = "49:51" %.

Printability tester printing pressure = 650 N. Printability tester printing speed = 3 m/s.

Research results:

A- The physical strength properties measurements results

The **dry basic physical properties** measurements results are summarized in the following table.

Tests / Samples — Physical Basic Properties	Measurement unit	Egyptian water-hyacinth uncoated offset paper	Imported WFU offset paper
Pulp stuff	-	(25 g\l NaOH – 75 min –130 C°) 1.5 to 2.0 mm length virgin waterhyacinth fibers.	Blend of virgin chemical wood + recycled chemical paper wastes.
Basis weight	g\m^2	60	80
Single sheet thickness	micron	140	85
Apparent Density	g\cm^3	0.0042	0.0094
Bulk	cm^3\g	238	106
Roughness "top"	ml/min	350	220
kappa number (lignin content)	-	14	5.3

Table (1): The basic physical properties results.

Note(1): *the drainage time of the waterhyacinths handmade samples was **12 min**! because of the too low freeness profile.*

While, the **dry physical strength properties** testing results are gathered in the following table.

Physical Strength Properties \ Tests Samples	Measurement unit	Egyptian water-hyacinth uncoated offset paper	Imported WFU offset paper
Folding Strength	double folds	54	80
Tensile strength	KN/m	2.1	4.6
Elongation percentage	%	0.4	1.6
Tear strength	mN	140	420
Burst strength	Kgf/cm^2	0.9	1.3
Perforation strength	N	7.5	17.7

Table (2): The physical strength properties results.

B- The solid printability parameters testing results

The following table contains the samples **dry optical properties** values

Optical Properties \ Tests Samples	Egyptian water-hyacinth uncoated offset paper	Imported WFU offset paper
Whiteness	70	110
60° Gloss	34 GU	80 GU
457 nm ISO brightness	80%	90%
Opacity	85%	88%

Table (3): The optical properties values.

Note(2): *the imported WFU samples having Fluorescent Whitening Agents \ FWA_s & Optical Brightening Agents \ OBA_s mixed with their pulp, which raise their whiteness & brightness profiles subsequently.*

Note(3): *the waterhyacinths fibers are unbleached ones.*

After 24 hours of complete absorption and oxidation ink films drying, the solid density & the optical 60^o gloss profiles averages of the 10 samples with different (gradual) ink coverages were measured. **Table (4)** shows these measured averages.

Those results had been used for calculating precious ink requirement factors of both the solid density & the optical 60^o gloss.

Tests Samples / Ink Coverage	Egyptian waterhyacinth uncoated offset paper		Imported WFU offset paper	
	Solid density	60^o gloss	Solid density	60^o gloss
8.1 g/m^2 "Too high"	2	4.7	2.4	6.2
5.7 g/m^2 "high"	1.7	4.2	2.02	5.1
4.12 g/m^2 "Typical"	0.98	3.6	1.41	4.6
1.9 g/m^2 "Low"	0.54	3.3	0.77	3.7
0.66 g/m^2 "Too Low"	0.33	3.1	0.45	5.3
Average **4.09** g\m^2	1.11	3.78	1.41	4.98

Table (4): Solid density & optical 60^o gloss profiles averages.

While **table (5)** renders the solid densities & optical 60^o gloss absolute variations averages measured from 5 fixed points on all the 5 Egyptian waterhyacinths uncoated offset paper samples and the 5 imported WFU samples, with 2 mm interval distance between each two subsequent points.

The variations averages were used to determine the printing unevenness "noise or mottling" profiles.

Tests / Samples / Measure Points	Egyptian waterhyacinth uncoated offset paper		Imported WFU offset paper	
	Solid density	**60^o gloss**	**Solid density**	**60^o gloss**
Average values with the ex-mentioned gradual ink coverages				
a + 4 mm	1.18	3.1	1.41	4.8
b + 2 mm	1.2	3.3	1.4	4.83
c "Stripe center"	1.15	3.7	1.42	4.9
d - 2 mm	1.17	3.9	1.41	4.84
e - 4 mm	1.16	4.02	1.42	4.75
Absolute variations sums between the measuring points	0.24	4.97	0.09	1.49

Table (5): Solid densities & optical 60^o gloss absolute variations averages.

Results analysis:

A- The physical strength comparative analysis

The imported WFU offset paper has **surpassed** the Egyptian waterhyacinths uncoated offset paper in the all measured physical properties:

- The folding strength.
- The perforation strength.
- The tear strength.
- The burst strength.

No one of the Egyptian waterhyacinths' lab made uncoated offset paper physical strength profiles has exceeded its parallel for the imported WFU samples.

B- The solid printability calculation & analysis

-The solid density ink requirement factor calculation equation:

Solid density ink requirement factor =

Applied ink coverage average / Measured solid density average

This factor is used to determine the needed ink coverage for obtaining a required solid density, on any paper grade, that's according to the next equation:

The needed ink coverage "g/m^2" = Ink requirement factor × The required solid density

By the same way, we can calculate & use the optical gloss ink requirement factor, for a certain paper grade.

- The solid density or optical gloss unevenness calculation equation:

Unevenness average =

The sum of measured absolute variations / The number of measured variations

By applying the previous equations on the printability tests results displayed in tables **(4)** & **(5)**, I managed to complete the next table.

Tests Samples / Printability Parameters	Egyptian water-hyacinth uncoated offset paper	Imported WFU offset paper
Solid density ink requirement factor	3.68	2.9
Optical 60^o gloss ink requirement factor	1.08	0.82
Solid density unevenness average	0.024	0.009
Optical 60^o gloss unevenness average	0.497	0.149

Table (6): The solid paper printability parameters profiles.

Table (6) indicates that:

- The **lowest** solid density ink requirement factor has been achieved by the imported WFU offset paper, with the value of 2.9. While the **highest** factor was for the Egyptian waterhyacinths offset paper, with the value of 3.68.

- Also, the **lowest** optical 60^o gloss ink requirement factor has been achieved by the imported WFU offset paper, with the value of 0.82. While the **highest** factor was for the Egyptian waterhyacinths offset paper, with the value of 1.08.

- The solid density unevenness average for the **Egyptian waterhyacinths** offset paper was **too higher** (with around triple folds) than that for the **imported WFU** offset paper.

- The optical 60^o gloss stability for the **Egyptian waterhyacinths** offset paper was **also too higher** (with around triple folds) than that for the **imported WFU** offset paper.

Results evaluation & findings:

Comparatively against the imported WFU offset paper sold in the Egyptian markets, and to characterize the **physical strength** of the Egyptian uncoated offset paper made manually in lab of waterhyacinths, we can judge that it's **too weak** and has **wide** tolerances apart from the European standards.

So it can be stated that the Egyptian waterhyacinths offset paper **can't** endure the normal tensile forces & the various loads of handling and circulation during printing.

To evaluate the **solid printability** parameters, the next scientific two principles has to be mentioned at first:

The **lower** the solid density & optical gloss ink requirement factors; the **fewer** the needed ink coverage for targeted densities & gloss values…and of course, the **better** the paper printability & the cheaper the printed unit cost "1 sheet or 1 m^2".

In a parallel way, the **lower** the solid density or optical gloss unevenness averages, for a specified ink coverage; the **better** the paper printability.

Applying the ex-principle on the solid density & gloss ink requirement factors obtained in our research here (**table 6**), we can very easily prove the **priority** of the imported WFU offset paper printability quality, comparatively against the lab made Egyptian waterhyacinths offset paper.

Also by taking the solid density & gloss unevenness averages, as our printability evaluation parameters; the late sequence will **still the same**.

References:

1. Levin Jan-Erik & Soderhjelu Liva **"pulp and paper testing"** - Papermaking science and technology series. Book 17, PP "137 – 163", p"252", pp "199 - 211" - Finnish paper Engineers' Association & TAPPI. Series ISBN: 952-5216-00-4. Book ISBN 952-5216-17-9. Finland. 1999
2. Paper, board and pulp ISO Standeds Handbook 23, ISO, Geneva, 1998.
3. Prikko Oittinen & Hannu Saarelma **"printing"**- Papermaking science and technology series. Book 13, pp "231 - 237" - Finnish paper Engineers' Association & TAPPI. Series ISBN: 952-5216-00-4. Book ISBN 952-5216-13-6. Finland. 1998.
4. TAPPI Test Methods "1996 / 1997", TAPPI press, Atlanta, 1996.

5. “Waterhyacinth as a potential plant in a paper fatory”. L.S.Widyanto,A.Sopannata & Usman S.Friend. J.Aquat.Plant Manage.21:1983.
6. “The papermaking properties of Waterhyacinth”. W.J.Nolan & D.W.Kirmse. University of Florida, Chmeical Engineering Department.