1. Introduction:

1.1Background:

The term recycling can be defined as the process through which materials previously used are collected, processed, remanufactured, and reused .[1]

Paper is a thin material produced by pressing together moist fibers of cellulose pulp derived from wood, rags or grasses, and drying them into flexible sheets. It is a versatile material with many uses, including writing, printing, packaging, cleaning, and a number of industrial and construction processes [2]

We live in a throw away society, and much of what we throw growing rubbish mountain is paper: paper makes up about 35% of total household waste volume. Driven by the anxieties of environmentally concerned citizens, many countries have introduced legislation designed to reduce waste very quickly. Among the main arguments behind the popularity of planning materials recovery from the starting point of "closed loop recycling" is the general belief in less consumption of resources, less energy consumption, cheaper production costs, and an overall reduction of environmental load through recycling.[3]

The problems of resource depletion, pollution, paper consumption, and paper waste are serious and inseparable. While world waste paper consumption doubled between 1965 and 1982, recycling rates increased by only 4 percent, from 20 percent in 1965 to 24 percent in 1982 [4]

On the national level, during an averageseventy-year lifetime, an average American will use directly or indirectly morethan 19 tons of paper or approximately 600 pounds of paper per year.[4]

This rate of paper consumption is about nine times the world's average, and aboutforty-six times the rate in less developed nation and results in millions of treesbeing cut down annually to satisfy the demand for paper products in the UnitedStates.Yet the United States has one of the lowest recovery rates for paper (27%) in the industrialized nations. This low rate of paper recovery also explains why paper and paper products makes up between one-third to one-half of the estimated 150 million tons of "garbage" being produced by Americans each year.(4)

Chandler estimates that if half the paper used in the world today were recycledit could meet almost 75 percent of the demand for new paper and would preserve 20 million acres of forestland an area equivalent to 10 percent of Europe's forest. It has been estimated that if a 50 percent recycling rate were realized within the United States it could save a 150 million trees and conserve enough energy toprovide 10 million people with a year of residential electricity.(4)

In addition to saving land, trees, energy and money, paper recycling ultimately reduces air and water pollution, conserves water, decreases carbon dioxide buildup in the atmosphere (and thus may help delay climatic changes), preserves habitats and genetic diversity, decreases soil erosion and flooding and reduceshealth hazards due to pollution compared to the health hazards from making paperproducts from virgin timber.(4)

Paper recycling is being strongly promoted in several countries. Recovery rates have increased worldwide. Japan recycles some 50 percent of its wastes (and incinerates 34%), although some questions have arisen as to what materials are or are not counted in these figures. Perhaps most encouraging is the growing awareness within industry that it is profitable to recycle waste that otherwisewould have been released into the

environment.[4]

Obviously, recycling is a means of reducing waste streams and, accordingly, reducing the demands for waste-treatment capacity. It is perhaps less obvious that increased recycling may also actually *increase* the consumption of nonrenewable resources. [3]

There is a growing awareness of the need to radically decrease waste streams from production and consumption processes. This awareness has not only brought about the implementation of improvements in processes but has also led to increased circulation of materials. Unfortunately, industry has not always been able to make use of all reusable materials available; on the other hand, collection of the materials for reuse has not been as efficient as was estimated or expected. This has led to increasing frustration amongboth consumers and industry toward policy makers. To a large extent, this dilemma has arisen from the incompatibility between the goals of policy makers and the actual possibilities of rapid changes in production processes and consumer behavior. This incompatibility could only be avoided by setting more realistic goals for the reduction of waste streams, thereby reducing the excess costs resulting from inefficient policies. [3]

The sheer volume of waste, particularly solid waste, complicated by limited waste- in management resources, has led to changes consumer behavior, to the introduction of legislation intended to reduce waste volume, and to great improvements in industrial technology. For example, during the past 20 years, despite increased production, the total wastewater discharge from paper and pulp production in some Western European countries has been halved, and the total biological oxygen demand (BOD) load reduced to one-third its former value (National Board of Waters and the Environment, Finland). [3]

Driven by the concerns of environmentally concerned citizens, many communities and countries have introduced legislation designed to reduce waste very quickly. For example, the British target is a 50% overall recovery of recyclable household waste by the year 2000 (UK Environmental Protection Act), the German target is 80% by July 1995 (German Dual System Regulations), and the Ee target is 60% by the year 1996 (Draft Directive on Packaging) In the Netherlands, industry has undertaken to reuse at least 60% of material, so that by 1995 the amount of packaging currently going to landfills will be reduced by 60% (Environmental News, 1991). [3]

Targets for materials recovery are set, in particular, to provide substitutes for primary materials in the manufacture of goods. But recovery of materials as substitutes for fuels in energy production is currently often excluded from political recovery plans, even though the development of incineration technology and the reduction of heavy-metal, chlorine, and other contaminants in wastes might be an essential future strategic alternative. [3]

One of the main arguments behind the popularity of planning materials recovery from the starting point of *closed loop recycling* is the general belief in the overall reduction of environmental load through recycling. Obviously, recycling is a means of reducing waste streams and, accordingly, reducing the demands for wastetreatment capacity. But, on the other hand, recycling may have the opposite effect of increasing demand for resources. The facilities and activities required for managing recycling, and the need to add material to compensate for quality degradation, consume energy and materials. [3]

Paper differs from other basic material in Western Europe (and also in the rest of the world) in several fundamental ways. First, paper comes from a

renewable source. Second, it possesses a high energy potential. Third, because of geo-climatic circumstances, the centers of consumption and the sources of raw material are far apart. Because of renewability, the application of the principle of sustainability to paper should be focused on managing the wood balances rather than overall minimization of the use of raw wood material. In addition, the energy potential of paper should be taken into account as an alternative to nonrenewable energy sources. Utilizing the heatpotential ofwaste paper represents an essential way of both saving nonrenewable resources and minimizing solid wastes. (3)


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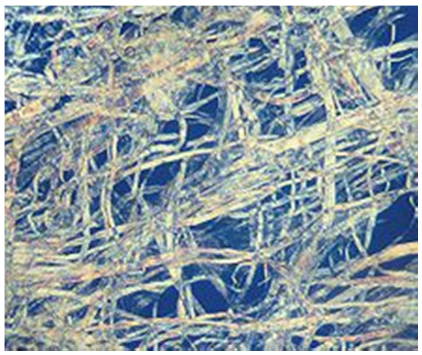


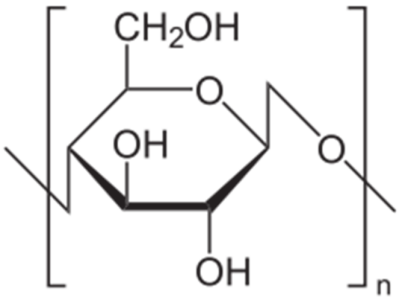


Table 1 printing type and the volume of printed ink for painted and unpainted ink

Printing type	unpainted papers (µm)	painted papers (µm)
Letter Press	2-30	100-10
Offset	30-2	100-5
Flexography	1-0.3	2-0.7
Gravure	30-2	30-2
Lazer/Xerox	400-40	400-40

Table 2 Data that explains the usage of Sudan from papers :

Type of paper	Quantity Tons / per month	Examples of papers used
1/ packaging paper	9000	Cardboard
2/ duplex paper	30,000	Candy papers, medicine papers , tea boxes
3/ office paper	20,000	A4
4/ printing paper	22,000	School books
5/ newspapers	600	newspapers
6/ tissues papers	50	tissues
7/ socks papers	2000	Cement bags

The usage of papers in Sudan monthly costs 60 million dollars .

1.2 Methodology:

The process of waste paper recycling involves mixing used paper with water and chemicals to break it down. It is then chopped up and heated, which breaks it down further into strands of cellulose, a type of organic plant material; this resulting mixture is called pulp, or slurry. It is strained through screens, which remove any glue or plastic that may still be in the mixture then cleaned, de-inked, bleached, and mixed with water. Then it can be made into new recycled paper. (4)

There are three categories of paper that can be used as feed-stocks for making recycled paper: mill broke, pre-consumer waste and post-consumer waste.(4)

Mill broke is paper trimmings and other paper scrap from the manufacture of paper, and is recycled internally in a paper mill.(4)

Pre-consumer waste is material which left the paper mill but was discarded before it was ready for consumer use.(4)

***Post-consumer* waste** is material discarded after consumer use, such as old corrugated containers (OCC), old magazines, and newspapers.(4)

Paper suitable for recycling is called "scrap paper", often used to produce molded pulp packaging. The industrial process of removing printing ink from paperfibers of recycled paper to make deinked pulp is called deinking , an invention of the German jurist Justus Claproth.(4)

1.3 Objectives:

- **Social objectives :**

1- Feeling the responsibility of the mission of recycling paper.

2- Participation in the programs of recycling paper gives the feeling of duty towards the society.

3- Recycling paper limits pollution.

- **Environmental objectives :**

1- Recycling paper saves energy.

2- Recycling paper conserves natural resources.

- **Economical objectives :**

1-Recycling paper supports several sectors of the economy.

Recycling one ton of paper can save 17 trees, 7,000 gallons of water, 380 gallons of oil, 3.3 cubic yards of landfill space and 4,000 kilowatts of energy-enough to power the average home for six months-and reduce greenhouse gas emissions by one metric ton of carbon equivalent .[(5)]

2. Literature survey

2.1 Who Recycles?

Research taking the personal approach to the study of recycling behaviors has explored several different types of variables. These personal variables can be broken down into four basic classes: environmental attitudes, knowledge, demographic variables, andpersonality variables.(1)

2.2 Environmental attitudes:

Research into attitudinal predictors of recycling behavior has examined both general concern for the environment and specific concern regarding a particular issue. The hypothesis that people who are more concerned with general environmental issues are more likely to recycle is a special case of the issue of correspondence between attitudes and behavior (Ajzen&Fishbein, 1977; Rokeach, 1979). Although attitudes often are not strong indicators of behavior, they frequently have been found to be significant predictors (Wicker, 1969).(1)

Research findings regarding the relationship between attitudes and recycling behaviors have been generally consistent with attitude-behavior theories. The majority of reported studies, investigating the abilityof general environmentzil concern to predict recycling behaviors, have found significant, though relatively small relationships.(1)

Schultz and Oskamp (1994) reviewed eight assessments of the relationship between environmental concern and recycling behaviors. Of the eight assessments, five reported a positive relationship, whereas three reported no significant relationship.(1)

Analysis of the research indicated that the time period in which the study was conducted seemed to affect the results. All the studies conducted prior to 1980 reported a positive relationship, whereas three of the four studies reported in the 1990s reportedno relationship.(1)

One possible explanation of this difference might cite the fact that articles reporting no relationship are usually not published unless they contest a previous finding. Thus, early studies in any area tend to report a significant relationship, and later studies may contest it. the issue of correspondence between attitudes and behavior (Ajzen&Fishbein, 1977; Rokeach, 1979). Although attitudes often are not strong indicators of behavior, they frequently have been found to be significant predictors (Wicker, 1969).[1]

2.3 Knowledge:

Knowledge about the recycling program has been found to correlate with recycling. In general, the more information a person has about which materials are recyclable, or where recyclables are collected, the more likely that person is to recycle. Oskamp etal. (1991) suggested that recycling behaviors may be less related to knowledge about global environmental issues than to knowledge about the specifics of recycling.[1]

Three studies found knowledge to differentiate recyclers from nonrecyclers. Vining and Ebreo (1990) argued that the greatest difference between recyclers and nonrecyclers is their knowledgeof collectable materials. In their study of 197 Illinois households, they found recyclers to have significantly more knowledge about recycling than non-recyclers. Gamba and Oskamp (1994) and De

Young (1989) found similar results.[1]

2.4 Demographic variables:

Before turning to the relationship of recycling and demographic variables, a brief mention should be made of the relationship of demographics to general environmental concern. Past research findings have indicated that people with the highest level of environmental concern tend to be young

(Butte1 & Flinn, 1976; Mohai & Twight, 19871, female (Mc Stay & Dunlap, 1983; Stern et al., 19931, better educated (Arbuthnot, 19741, higher earners (Van Liere & Dunlap, 19801, urban dwellers (Butte1 & Flinn, 1976; Van Liere & Dunlap, 19801, and ideologically liberal (Dunlap, 1975; Schultz & Stone, 1994) (for an earlier review, see Weigel, 1977).(1) Although these variables frequently have been correlated with environmental concern, their relationship torecycling behavior has been less consistent. In studies on recycling behavior, the four most often reported demographic variables are age, gender, income, and education. Five recent studies reported findings on age and recycling.(1)

In a study of commingled curbside recycling. Gamba and Oskamp (1994) reported a small significant negative correlation of age to self-reported recycling. Oskamp et al. (1991) found no relationship between age and selfreported recycling among community residents in a voluntary curbside recycling program. Vining and

Ebreo (1990) and Lansana (1992) both reported a positive relationship, indicating that older residents are more likely to recycle. In a national sample of community recycling programs. Folz and Hazlett (1991) found that, across communities where recycling was mandatory, the median age was significantlynegatively related to recycling as measured by the rate of waste diversion, but the two variables were significantly positively related in communities having voluntary recycling programs. Overall, the results of these studies are ambiguous as to both theexistence and direction of the relationship between age and recycling.(1)

Education has been investigated as a possible predictor of recycling behavior. Of the six studies that reported on the relationship between education and recycling, three found no relationship (Hopper & Nielson, 1991; Oskamp et al., 1991; Gamba & Oskamp, 19941, whereas the other

three reported a positive relationship (Webster, 1975; Vining & Ebreo, 1990; Lansana, 1992).(1)

The disparate results may be due to the range of education levels included in the samples. All three studies that failed to find a relationship between education and recycling were based on fairly affluent samples, whereas the three studies that found positive relationships were based on samples with a wider range in education levels.(1)

Research findings regarding the relationship of gender to recycling are clear. Five studies that studied the relationship between gender and recycling were unanimous in 6nding no significant relationship (Webster, 1975; Vining & Ebreo, 1990; Hopper &Nielson, 1991; O& et al., 1991; Gamba & O&, 1994). Thus, men and women are equally likely to recycle. Because recycling is often a household behavior, the person doing the recycling on a givenoccasion may be replaced by a person of the opposite gender on other occasions.(1)

Unlike gender, income has consistently been found to correlate positively with recycling behavior. Jacobs et al. (19841, Vining and Ebreo (1990), Oskamp et al.(19911, and Gamba and Oskamp(1994) all reported a significant positive relationship. People who make more money are more likely to recycle than people who make less money.(1)

The relationship of ethnicity to recycling has not received much research attention. Howenstine (1993) studied household recycling behavior reported by 574 Chicago college students in a sample whose ethnic diversity appeared representative of the surrounding community. Results indicated that 28% of Asians, 28% of Blacks, 12% of Hispanics, and 51% of Whites claimed to recycle. However, this assessment did not consider possible third variables (e.g. parental education, income, or occupaton).(1)

Overall, research on demographic variables has found that higher income appears to predict recycling behavior whereas the person's gender does not.(1)

Research findings on education are less uniform but suggest the possible existence of a relationship between greater education and recycling. The findings for age are contradictory, and too few studies have examined ethnic differences to reach any conclusions.(1)

2.5 Personality variables:

Few studies have assessed the relationship between personality constructs and recycling behavior, though there has been a limited attempt to define a recycling personality. In an early study, Webster (1975) argued that recyclers can be characterized as socially conscious consumers who have a high level of social responsibility. That is, recyclers participate in recycling programs because they believe they have a duty to society, and because they feel they can make a difference. In a sample of 250 urban households, Webster (1975) found that recyclers scored higher than nonrecyclers on both a socially conscious consumerism scale and a measure of social responsibility. Further, recyclers were more tolerant (as measured by the California Personality Inventory) than nonrecyclers, suggesting that recyclers may be less behaviorally rigid than nonrecyclers. The relationship between mental rigidity and recycling, though, has yet to be adequately explored.(1)

Simmons and Widmar (1990) also supported the finding that recyclers are charcterized by a feeling of responsibility. In questionnaire data from 500 households, recyclers were more likely to 'feel a sense of responsible action' than nonrecyclers. The authors argued, however, that responsibility is not enough-only when it is coupled with knowledge about recycling programs does social responsibility predict recycling

behavior.(1)

The idea that recyclers believe they can make a difference gains support from the research onenvironmental concern, although the link between environment alconcern and recycling is not strongly established. Several studies (Arbuthnot, 1974;

Borden & Francis, 1978; Hines et al. 1986-1987) have found concern for the environment to be associated with an internal locus of control, which can be defined as a belief that a person can determine his/her own destiny (Lefcourt, 1982). Although the relationship between internal locus of control and recycling apparently has only been directly tested by one study (Arbuthnot, 1974), it appears that the relationship may be positive.(1)

From the above review of personal predictors of recycling, there emerges a tentative list of demographic and personality variables that may be associated with recycling. However, the percentage of variance in recycling behavior accounted for by individual variables is probably small. In an analysis of community characteristics that predict recycling, Folz and Hazlett (1991) concluded**:**

Recycling success, as measured by participation and diversion, is clearly not dependent upon city socioeconomic characteristics or other political features of the community.(1)

What explained large portions of the variance in recycling performance among cities with different programs were the specific recycling policies adopted and other features related to the program's operation.(1) Thus, although some personal variables may be related to recycling behavior, it is necessary to examine situational variables to account for a larger portion of variance in recycling.(1)

2.6 Situational Factors-Antecedents:

Over the last 20 years, researchers have attempted to apply behavior analysis methods to problems pertaining to the environment, and more specifically to recycling behavior. The studies cited below are briefly summarized using an organizational framework earlier presented by Geller et al. (1982). These authors' framework can be applied to any behavioral intervention research area, including recycling, litter control, energy conservation, or transportation use (see also Geller et al. (1990). Briefly, the scheme classifies behavioral intervention strategies into two groups: antecedent and consequence interventions.[(1)]For other possible organizational schemes, see Cook and Berrenberg (1981), Gray (1985), and De Young(1993).[(1)]

Any intervention designed to increase recycling behavior by altering a variable prior to performance of the behavior (e.g. collecting recyclables, delivering recyclables to a collection center) is classified as an antecedent strategy. Five types of antecedent variables have been studied: prompting, commitment, normative influence, goal-setting, and removal of barriers to recycling. In the following review, when the data permitted it, effect size estimates have been computed for each intervention. The effect size estimates are reported either as Cohen's d, or as d'. Cohen's d is a standard metric intended for comparing results across studies (Cooper & Hedges, 1994), defined as the difference between sample means divided by the average standard deviation. The other metric reported in the table, d', is simply the difference between two proportions, namely the treatment and the control conditions, and is reported in cases where information on standard deviations was not available. Many of the studies reviewed failed to provide sufficient information to calculate an effect size estimate, and in these cases other indications of quantitative findings

are presented (e.g. experimental group significantly greater than control group).[1]

Because recycling has not attracted an abundance of research, few studies have been reported on each intervention. For these reasons, the effect size estimates are provided only as descriptive statistics. This is not a meta-analysis, and comparison across studies based on the available information would be unwarranted. [1]

2.7 Prompting:

Prompting represents the simplest, least expensive, and least intrusive of all the antecedent intervention strategies. In a prompting intervention, information(e.g. about the relevance of recycling to alleviatingsolid wast problems, or about the community's recycling program) is presented topotential participants before the recycling program begins (or continuingduring the program).[1]

This information can be factual, persuasive, or merely reminders, and it canbe delivered in writing, over the telephone, or inperson.[1]

Twelve studies have examined the effects of prompting on recycling behavior. Three studies showed that a single prompt aloneincreased recycling (Jacobs & Bailey, 1982; Oskamp, 1986; Burn, 1991). These three studies focused on curbside recycling, and the prompt was typically delivered in writing. A larger group of studies, however, showed enhanced effects of combining different communication approaches. Jacobs et al. (1984) found the addition of brochures increasedcurbside participation to a level two to four times that produced by newspaper ads alone. Spaccarelliet al. (1989-1990) found that an oral plea along with a written prompt resulted in a 22.1% increasein curbside participation, compared to a 2.4%increase in participation among residents receiving

only the written message. Arbuthnot et al. (1976-1977) found that prompts delivered as part of the Toot-in-the-door influence technique increased self reported recycling at communitydrop-off centers among new residents by 88%, compared to less than10% for each of the prompting strategies alone.(1)

Other studies showed that combining promptswith proximity of thecollection bin increased recycling. Austin et al. (1993) found that providingcontainers in convenient places and deliveringwritten prompts encouraged more people to recyclethan using prompts alone. Reid et al. (1976-1977)likewise found prompting and proximity togetherincreased recycling in apartment complexes bylOO%, 60%, or 50% (depending on the complex).(1)

How does prompting compare with other intervention approaches?

Few studies applying a promptingstrategy included another strategy for comparison.(1)

These studies (with one exception) agreed thatprompting alone is not as effective as otherapproaches in increasing recycling behavior. Forexample, feedback Goldenhar& Connell, 1992) orrewards (Witmer&Celler, 1976) increased collegestudents' recycling in special dormitory recyclingdrives, whereas prompting had no significant effect.(1) In contrast, both block leaders and promptingincreased participation in curbside recycling inBurn's (1991) study, although the block leadergroup participated at a higher rate than theprompting-alone group (average of 28% vs 12%, respectively). Burn and Oskamp (1986) found thatprompting, commitment, and the two strategies combined produced similar increases in curbsideparticipation (39%, 42% and 42%, respectively).(1)

Determining whether prompting can bring aboutenduring behavior change is difficult, because mostprompting studies used short-term time frames without follow-up measures. Five studies, however,measured recycling over a period of four monthsor longer, and two of these employed separatetreatment and follow-up periods.(1)

In these studies,prompting encouraged sustained participation incurbside and drop-off community programs, but notin the one study conducted in college dorms (Witmer& Geller, 1976). Vining and Ebreo (19891 reported a continued increase in the volume of materials collected during a 3-year, multi-media community campaign, and Spaccarelli et al. (1989-1990) showed a sustained increase in curbside recycling participation over 39 weeks. Burn (1991) found that the increase in curbside recycling still remained 12 weeks later, and Arbuthnot et al. (1976-1977) notedthat the increased number of new recyclers continued18 months following the implementation of the footin-the-door technique.(1)

Prompting may work better for some types of recycling than others. Most studies measured household recycling in community curbside or drop-offprograms, except for one study conducted in apartment complexes and three studies conducted withcollege students or staff. The prompting strategiesappeared to increase participation in communitydrop-off and curbside programs. In the apartment complex study, the effects of prompts alone couldnot be disentangled from proximity effects (distanceto the recycling bin area), and the effects were further confounded by increased bin capacity. Two of the three studies of special drives in college settings were the only studies not to show a positive effect of prompting on recycling.(1)

One major limitation of all these studies is the lack of consideration of the individual characteristics of recipients of thepromptsIn all studies reviewed here, results of the interventions were reported across all participants; however, it seems likely that people with more knowledge or environmental concern would be more strongly affected by promptsthan would participants low on these variables. In general, prompting interventions may be moreeffective with people who already have a favorableattitude toward recycling.(1)

2.8 Commitment interventions:

Commitment interventions are based on the principle that people become resistant to pressures to change their actions after making a decision to behave in a certain way (Oskamp, 1991).(1)

Seven studies have investigated the effects of commitment on recycling behavior, including public versus private commitment (McCaul& Kopp, 19821, written versus oral commitment (Pardini&Katzev, 1983-19841, and group versus individual commitment (Wang &Katsev, 1990). In most studies, commitment was initiated by requesting the research participant to sign a pledge or a statement.(1)

The two exceptions were (1) a public commitment condition, in which particpants were told that their names would appear in the college newspaper (McCaul& Kopp, 19821, and (2) an individual commitment condition, in which participants were asked in person if they would participate in the recycling drive (Wang &Katzev, 1990). Treatment generally lasted 2 to 6 weeks, with four studies including follow-up measures lasting from 2 to 4 weeks.(1)

After the seven studies, commitment produced increases in both curbside and special drive participation-not only during treatment, but also during

follow-up. These findings indicate a potential for long-term effects; however, the longest treatment period was 6 weeks and the longest follow-up period only 4 weeks.(1)

This short-term nature of all thecommitment strategy investigations precludes the ability to make statements with confidence about enduring effects of commitment on recycling behavior. Is there a difference among the types of conunitment (e.g. written, oral, individual, group)?(1)

Two studies actually compared various commitment approaches with each other. In these, written commitment produced greater increases than oral commitment in curbside participation and amount of recyclables collected (Pardini&Katzev, 1983-19841, and individual commitment yielded more participation than group commitment in a special recycling drive on a college campus (Wang &Katzev, 1990).(1)

Five studies, on the other hand, incorporated other interventions for comparison. Generally, commitment tended to produce longer lasting effects (i.e. on follow-up measures) than prompting or 114 P. W. Schultz et al. rewards. Pardini and Katzev (1983-1984) found oral and written commitment groups recycled more newspaper and had higher curbside participation rates than the information-only group during both the intervention and follow-up periods. In contrast, Burn andOskamp (1986) found commitment increased recycling 42% over baseline, but there was no significant difference between commitment and prompting as noted in Pardini and Katzev's study. Pardini and Katzev (1983-1984) suggested that commitment strategies may work because people who make such pledges move beyond the external justification for recycling (signing or stating a pledge) and 6nd their own additional reasons for recycling. A competing explanation for the effectiveness of commitment interventions

is that the changes are due to social pressure. All of these studies reported the effectiveness of commitments in terms of participation in a community recycling program, or of the amount of material collected. Both of these variables are socially visible-putting the bin at the curb to be recycled may make both the participation and the amount of materials observable to other residents. An interesting question is whether this change in behavior is internalized. If the changes in behavior are due solely to the social pressure of being observed, then they have not been internalized. This may imply that the change in behavior will be short-lived, and that it will not generalize to other recycling settings that are less visible (e.g. work, school, or travel). Because the commitment studies lasted only between two andeight weeks, conclusions about long-term changesin behavior cannot be made from these studies.(1)

2.9 Normative influence:

The use of social norms to encourage recycling behavior is a relatively new approach. One social psychological strategy is to enlist community members to model recycling behavior and to persuade their nonrecycling neighbors to participate in the recycling program. As a naturally occuming example, Oskampet al. (1991) reported that participation in a curbside program was higher for people whose friendsand neighbors recycled.(1)

Four studies have experimentally examined theeffects of social influence on recycling behavior.(1)

These studies (with one exception) indicated thatusing peer support to establish community recycling norms can increase and sustain recycling behavior. For example, Nielsen and Ellington (1983) found a 26-W weekly curbside participation rate over 5 months among blocks with an

identifiable recycling leader, as compared to 11.5% participation in blocks without a designated leader. Even when socioeconomic status and stability of neighborhood were held constant, results indicated that participation rates in blocks with block leaders were consistently higher than in blocks without leaders. Burn (1991) and Hopper and Nielsen (1991) found similar positive results. However, Oskamp et al. (1994) found no significant difference in the amount of recycled material, frequency of participation, or degree of contamination of the material recycled when a previously established block leader area was compared with that in a similar socio-economic area that did not have block leaders. As suggested earlier, the block leader approach has two potential sources of influence: information and personal contact.(1)

Two studies examined the effects of personal contact over information alone. Burn (1991) observed that block leader neighborhoods participated significantly more in curbside recycling, (58% of households recycled at least once during post-treatment) than the group receiving information left at the door (38% recycled at least once). The effects of both interventions did not diminishover the 12-week post-treatment period. Hopper andNielsen (1991) found similar results.(1)

In sum, block leaders may be effective because they serve as initiators of social norms within their neighborhoods. The desire for social recognition maymotivate nonrecycling neighbors to begin recycling, and this behavior may in turn be reinforced through social approval.(1)

Personal contact by the block leader may also prompt public commitment, which in turn could initiate recycling behavior. Although the block leader approach has yet to be thoroughly assessed, it appears to have the potential to produce longterm changes in recycling behavior,

although the findings of Oskamp et al. (1994) suggest that the strategy may not always work. Furthermore, the use of volunteer block leaders in neighborhoods presents a cost-effective intervention for communities.(1) As with the previously discussed interventions, studies conducted on social norms failed to consider any characteristics of the community. For example, residents who perceived themselves as part of the community may be more affected by this intervention than residents who feel isolated or alienated. It seems likely that rural residents may be more affected by social norms than residents of an urban community, and likewise home owners may be more affected than renters and apartment dwellers.(1)

The successful use of social pressure to induce recycling may be largely contingent upon the extent to whichresidents see themselves as part of the community.(1)

2.10 Goal-setting:

Coal-setting involves the specification of a set target of material to be reycled. In his correlational study of community recycling programs, Folz (1991) found that cities which established a goal to recycle a specific proportion of the waste stream reported significantly higher levels of citizen participationin municipal recycling programs than cities whichdid not establish a goal.(1)

Only two studies have experimentally assessed the effect of goal-setting on recycling. These studies both found significant effects in increasing the amount of materials collected in special recycling drives at an elementary school (Hamad et al. 1980-1981) and a college (McCaul&Kopp, 1982). However, the persistence of behavior change was not tested, and since both studies used special populations, questions remain regarding thegeneralizability of the results to community

residents.[1]

Students who spend many hours of the week together may develop a sense of cohesiveness that, in turn, may motivate efforts toward common goals.[1]

Making goals salient and important to members oflarger groups, such as communities, may be a more difficult task.[1]

2.11 Removing barriers to recycling:

All recycling programs involve effort on the part ofthe participant. One of the most direct, but often overlooked, ways to increase recycling behavior is the removal of barriers to recycling. Simply stated, this strategy attempts to reduce response costs by minimizing the amount of effort required to recycle.[1]

Three barriers to recycling have been studied: distance of the collection location from the participant, method of collection, and sorting of recyclable materials. Distance. Most older recycling programs involved depositing materials in a central location. From an administrative perspective, this reduces the cost of the program. From the participants' perspective, however, the use of a central collection location adds personal costs of extra time and effort involved in the transportation ofrecyclabales to the collection center.[1]

Three studies have experimentally examined the effect of increased bin proximity on recycling participation (Reid et al., 1976; Humphrey et al., 1977; Luyben& Bailey, 1979).[1]

While these studies are few in number, they consistently indicated that the closer participants are to the collection center, the more likely they are to recycle. For example, Luyben and Bailey (1979) found a 47% average

increase in drop-off recycling participation in a mobile home park following the placement of six additional bins throughout each park.(1)

These additional bins increased each resident's proximity to a bin and thus reduced the extra costs of transporting materials. One limitation of research on proximity is the short-term duration of studies. Recycling wasmeasured over periods ranging from 3 weeks inReid et al. (1976) to a high of 10 weeks in Humphrey et al. (1977). On the other hand, a strength of this research is that proximity was shown to work in a variety of situations-apartment complexes (Reid et al., 19761, mobile home parks (Luyben& Bailey, 1979), and offices (Humphrey et al., 1977).(1)

Several other studies reporting non experimental findings support the claim that proximity to a collection center positively affects recycling.(1)

Witmerand Geller (1976) reported that students whose dorm rooms were closest to the collection center showed the highest level of participation in a paper recycling program. Cummings (1977) found that among 432 New York City residents, proximity to avoluntary recycling drop-off center was signScantlypositively related to participation in the program.(1)

Collection method. A second barrier to recycling among home owners is the collection method. Folz(1991) examined differences between communities with a curbside collection program and ones using a drop-off location. His analysis revealed a largesignificant difference in estimated participation rates.

Communities with vuluntary curbside collection had an estimated 49% participation rate, compared to 25% for communities with drop-off collection. This finding suggests that removing the need totransport materials to a central location can increaseparticipation rates.(1) The schedule of collection may also affect recycling participation.

Curbside recycling programs collect recyclable materials on afntedschedule, and in some cases the collection day for recyclables and for other refuse does not coincide. It seems likely that participation in recycling programs would be higher if both recyclables and other refuse were collected on the same day, and at frequent intervals. The single reported study on this topic found that cities with same-day pick-up of recyclables and other refuse did not report higher participation rates in recycling programs than cities with different-day collection schedules (Folz, 1991). However, this findingcombined reports on mandatory and voluntary programs and had other possible confounding factors.(1) Sorting. A third barrier to recycling is the effort required to sort materials. Asking participants to 116 P. W. Schultz et al. sort recyclable8 into different bins is common in home recycling programs. As participants begin to recycle more types of materials, they may find themselves separating those materials into numerous bins. In some German cities, for example, apartmentcomplexes have up to seven different bins in whichto place different materials.(1)

An alternative to having participants sort their recyclable8 is to use commingled recycling, in which participants place all recyclables mixed together in asingle collection bin. The materials are then collected and sorted at a materials recovery facility, using both mechanical and manual techniques.(1)

This recycling method requires less effort by the participant. Gamba and Oskamp (1994) examined household participation rates in a city-wide commingled curbside recycling program. They found that over 90% of the households participated in the program at least once in five consecutive occasion-an amazingly high figure-whereas earlier, in a voluntary separated recycling program, less than 40% of city residents

were estimated to take part. In contrast, Folz's (1991) correlational study across 264 cities concluded that requiring separation does not significantly decrease participation in recycling programs. In his analysis of municipal recycling programs, both mandatory and voluntary, there was no difference in the estimated average participation rates for programs that required separation and those that did not. The many other uncontrolled differences among cities in his study, however, make generalization of its findings questionable. Clearly the topic of separation requires further research.

Summary:

In sum, the research data regarding antecedent intervention techniques indicate that many types of interventions have been successful in increasing recycling behavior for the duration of the intervention.(1)

Commitment, norms, prompts, goals, and the removal of barriers all can produce significant increases in recycling behavior. Several clear limitations, however, exist in the literature. First, the persisting effects of these strategies remain largely untested. Written personal commitment apparently increases recycling for a longer period oftime than do extrinsic rewards, but the length of time that commitment affects recycling is unclear, because six weeks is the longest follow-up period over which its effects have been demonstrated.(1)

As De Young (1993) emphasized, the durability of program effects is a crucial issue for research intended to be relevant to public policy issues. Second, the relative effectiveness of different antecedent interventions has yet to be assessed. It seems likely that these interventions are more effective with people who already have favorable attitudes toward recycling. Third, almost all reported studies have employed single

measures of recycling. As was pointed out above, interventions may have differential effects on different recycling variables (e.g. amount,frequency of participation, and contamination).(1)

2.12 Situational Factors-Consequence Variables:

Any intervention that attempts to modify recycling behavior by presenting a consequence (i.e. feedback of information, a reward, or a punishment) contingent upon the behavior is classified as employing a consequence strategy. The majority of empirical studies in this recycling area, however, examined the effects of rewards. No reported study hasassessed the effect of punishment on recycling(probably for ethical reasons).(1)

Rewards:

Eight studies directly tested the effect of rewards on recycling behavior. This strategy is based on learning theory, which suggests that external contingencies or rewards will make a behavior more appealing and induce behavior change (Geller, 1989). All eight studies found that offering rewards (e.g. money, coupons, or lottery tickets) significantly increased the amont of material people will recycle.(1) Furthermore, chances to win lottery prizes generally had stronger effects than did small cash payments, and individual rewardstypically produced larger increases in recyclingbehaviors than did group rewards.(1)

Comparisons of reward intervention with other interventions suggests that rewards can produce larger changes in behavior. For example, rewards have been found to produce larger changes than prompting (Geller et al., 1975; Needleman & Geller, 19921, information (Diamond & Loewy, 19911, goal setting combined with feedback (Needleman & Geller, 19911, and group commitment Wang &Katzev, 1990).However, despite

the potential of reward interventions, there are several drawbacks.(1) First, the change in behavior produced by reward programs was short-lived, for after termination of a reward program, recycling behavior typically returned to baseline levels (cf. Katzev& Johnson, 1987). The incentives used in these studies may not have facilitated long-term behavior change for several reasons. First, the rewards may have lost some of their novelty as time passed, and participants may have found that other factors, such as timeand effort, outweighed the attraction of the reward.(1)

Second, the rewards may not have been meaningful to all particpants or substantial enough to catch participants' interest; this poses the problem of developing attractive incentives for diverse groups of people. Third, the imposition of external motivators may have masked or reduced internal benefits derived from recycling behavior, as in the social psychological research literature on over justification effects (e.g. Lepper& Greene, 1975). Furthermore, the cost of supplying rewards and organizing theiradvertisement and distribution often outweighs theeconomic benefits of recycling.(1)

Another issue concerning reward interventions is the extent to which behavior change produced for rewards of one material (e.g. aluminum cans) willgeneralize to other materials (e.g. newspaper).(1)

Needleman and Geller (1992) examined this issue in their study of recycling at a worksite setting. Employees were rewarded with an entry into a drawing each time they returned aluminum cans for recycling.(1)

Results showed that there was a significant increase in the amount of aluminum cans recycled, but no increases for other materials (e.g. newspaper, glass). This finding suggests that reward interventions are

only effective in increasing behavior related to the specific material targeted with the reward, and that the changes in recycling behavior do not generalize to other materials.(1)

Although rewards appear to provide powerful short-term changes in recycling, two unanswered questions are evident.(1)

First, whose behavior is changing? Studies reviewed above on specific attitudes found nonrecyclers to be more concerned withfinancial issues than recyclers. This finding leads to the hypothesis that offering rewards will be moreeffective with people who are not currently recycling.(1) Secondly, as with all previously reviewed studies, only single assessments of recycling have been studied in this literature. Most of the eight studies examined the amount of material collected, which was the rewarded behavior. However, if the rewards had been offered for frequency of participation, or quality of recycled material, rather than amount, differentresults might have been obtained.(1)

Feedback:

Another important aspect of consequences is the effect of feedback strategies on recycling. Presenting people with feedback about their behavior has been successful in decreasing energy and water consumption, typically by amounts in the lo%-15% range (Se&man& Darley, 1977; Se&-man et al., 1981). However, despite the success of the feedback technique in other arenas, only four studies have directly assessed its effectiveness in increasing recycling (Hamad et al., 1980-1981; Goldenhar& Connell, 1991-1992; Katzev&Mishima, 1992; De Young et al., 1995). Seligman et al. (1981) suggested that in order for feedback to be successful, several criteria must be met.(1)

First, people must be able to identify a relationship between their behavior and the feedback. This requirement is met most effectively by providing immediate feedback. For example, when thermostats are combined with meters that indicate energy consumption rates, people can observe the effects of their behavior.(1)

Second, the individual must be interested in change; feedback is noteffective in changing behavior if the person has no desire to change. The desire to change is a strong mediating variable in the effectiveness of feedback interventions.(1)

The studies reported by De Young et al. (1995) and Hamad et al. (1980-1981) failed to find a significant change in behavior, whereas Katzev and Mishima(1992) and Goldenhar and Connell (1991-1992) did find a signif&.& increase in recycling. The two studies that reported a significant effect were conducted in the 1990s with college students, who are in general more liberal, educated, and higher SES than average. The study by De Young et al. was conducted on a sample of apartment residents, and the study by Hamad et al. was conducted in the early 1980 on school children-both groups being qualitatively different from college students. It seems likely that the feedback interventions were effective because the college student participants in the study were interested in change. Clearly more research isneeded on the effects of feedback on recycling.(1)

2.13 Discussion:

Overthe last 20 years, social scientists have attempted to identify effective techniques to encourage recycling. As the solid waste crisis continues to escalate, city and county officials are experiencing greater pressure to find ways to sustain a high level of waste diversion. Policy-

makers and community leaders are asking social scientists which intervention, or set of interventions, produce the best results. A definitive answer to this question is d3Ecu.h given the current state of the literature. Although 118 P. W. Schultz et al. an understanding of who recycles, and when, is beginning to emerge, several clear limitations need to be addressed.(1)

First, the answer concerning which intervention is the best depends largely on the desired outcome of the intervention. To date, nearly all empirical investigations of recycling interventions have measured a single dependent variable, usually either the percentage of participants in the recycling program (new or continuing) or the amount of material collected. A third potential variable is the quality of the collected material. As the percentage of nonrecyclable material collected in the recyclingprogram (termed contamination) increases, theusability and value of the collected material decreases.(1)

Only one study has examined all three dependent variables, and it found different effects for each variable (Oskamp et al., 1994). Overall, different recycling interventions may affect different aspects of recycling. For example, some prompting interventions (i.e. informational ones) may decrease the amount of contamination, but be ineffective atincreasing either the number of recyclers, or theamount of material collected.(1)

Second, future research should examine the extended effects of various intervention strategies. many studies ex a mining situational variables have measured behavior changes against a baseline, followed by a second baseline period, and then by a second intervention. That is, more than one intervention is often applied to the same sample. Using this method precludes the collection of follow-up data. As recycling programs become more prominent, social scientists will be asked how to produce long-term

participation in recycling programs (De Young, 1993). This question is best answered byexamining the effects of two or more interventions over an extended period of time, on randomly assigned groups. Using separate groups for each intervention allows comparisons across conditions, and also allows for follow-up measures of each intervention.(1)

Third, empirical investigations of recycling interventions to date have explored either personal ofsituational variables. Such studies attempt to identify main effects: e.g. what type of person recycles, or what conditions are associated with more recycling. The next step for recycling research is to examine the differential effects of intervention strategies on various types of people. Research should look for interactions between the type of recycling program and characteristics of the individual-that is, interactions between person and situational variables.(1)

Fourth, the effectiveness of different interventions may depend largely on characteristics of the community in which the program is instituted. For instance, providing people with rewards for recycling may be more effective in increasing recycling among people low in environmental concern than among those high in environmental concern.(1)

People who are concerned for the environment are motivated to recycle for internal reasons; recycling makes themfeel they are helping to protect the environment (Simmons &Widmar, 1990). People low in environmental concern, on the other hand, do not have this internal motivation.(1)

External incentives to recycle might provide them with a motive and cause an increase in recycling. Many other potential interactions have been mentioned throughout thisreview.(1)

The idea that the type of intervention should be selected based on the desired outcome and the characteristics of the target population is an integral part of social marketing concepts (Bloom &Novelli, 1981; Geller, 1989).(1)

What we have advocated here as an interactional approach to research has also been described as 'market segmentation', i.e. partitioning a potential market for the product (the intervention) into homogeneous subgroups based on common characteristics. According to Geller (1989), this technique 'provides a basis for selecting target markets and developing optimal promotional programs for individual target segments' (p. 28).(1)

A fifth limitation of the current research is the unknown extent to which recycling one material predicts recycling of another (i.e. response generalization). Investigations of recycling behavior to date have examined the recycling of only one material, or of several materials combined-but not differential rates of recycling for different materials.(1)

Recycling behavior is ordinarily measured as the amount of newspaper, white paper, glass, plastic, or metal cans returned for recycling. It is implicitly assumed that both personal and situational variables found to predict recycling of one material will generalize to the recycling of another material. That is, people who recycle white paper are generally assumed to be more likely to recycle aluminium cans. This assumption is, in part, a reflection of the more general belief held by many researchers about the relationship among different pro environmental behaviors. Investigators of proenvironmental behaviors (e.g. recycling, litter reduction, water conservation, energy conservation, and purchasingenvironmentally safe products) have often assumed that, for

the most part, people who show a propensity for performing one proenvironmental behavior are likely to show a similar propensity for another. That is, someone who recycles should also conserve water, be an environmentally conscious shopper, etc. Further, these behaviors are often understood as the manifestation of an environmental ideology(Dunlap & Van Liere, 1978; Commoner, 1990).[(1)] In contrast, several studies have found that various proenvironmental behaviors are not closely related (e.g. Tracy &Oskamp, 1983-1984). For instance, Siegfried et al. (1982) used attitudinal and demographic variables to predict each of four proenvironmental behaviors (lowering thermostats, using less hot water, purchasing environmentally safe products, and avoiding the use of unnecessary lights). Their analysis failed to reveal a consistent pattern of predictors for the four behaviors. The authors concluded 'generalizations from one specific proenvironmental behavior to other forms of behavior may be inappropriate' (p. 288). Similar conclusionswere reached by Oskamp et al. (1991).[(1)]

In planning and developing interventions to improve recycling programs, the costs of each intervention play a large part in determining which type of intervention is selected, and how it is implemented. However, despite the practical importance of intervention costs, very few scientific studies report on costs.[(1)]

Expenses for interventions come from two source: materials used, and their distribution. Materials for interventions can range from simple flyers in the case of prompting, to cash lotteries for rewardinterventions. Once the materials have been prepared, the intervention must be delivered to potential recyclers. Interventions that require contact with each potential recycler (e.g. rewards, individual feedback, and commitment) are

typically more expensive. In contrast, interventions that can be delivered to recyclers without individual contact (e.g. group feedback, prompting, removing barriers) are less expensive. However, costs for interventions vary from setting to setting. A useful line of research would be an investigation of the amount of behavioral change produced per dollar, where dollar amounts include the expenditures for materials as well as a standardized estimate of the number ofperson hours required to develop and distribute theintervention.(1)

2.14 Previous research on paper recycling:

Some studies try directly to stimulate increased public participation in recycling programs; others try to identify the social and psychological factors which encourage or hinder recycling. In both cases, research has concentrated upon pilot or experimental recycling programs, mostly in academic settings, and occasionally in the general community.A common research approach is to offer people rewards (e.g., money, prizes,raffles, lotteries) for recycling their paper.(4)

These studies generally suggest that such inducements increase the quantity of paper recycled and the rate of public participation compared to control groups or baseline conditions Moreover, rewards that target the individual rather than the group have been foundto be more effective in increasing paper recycling.Yet it appears that (extrinsic) incentives by themselves promote only modestincreases in participation. When the incentives are removed, the participation rates generally return to original conditions . For that matter,McClelland and Canter concluded from their review of available studies thatthe effects of extrinsic rewardsare generally short-lived at promoting conservation behaviors in general.(4) Informational approaches such as prompts, posters, verbal and

writtenappeals, or feedback messages have also been used in concert with incentivesto foster paper recycling. Results suggest that participation rates and the amountof paper recycled are raised significantly more than with information alone.(4)

Research bears out that, as one might expect, participation rises when recycling is institutionally supported by providing readily accessible and convenient recycling opportunities along with written appeals. Apparently, an "Integrative Approach"combining institutional supports, information, and incentives is more successful in promoting paper recycling than any single strategy.(4)

While evidence has been rather limited, some socio-demographic characteristics appear to be associated with paper recycling. Persons with higher levels of education, income and socio-economic status seemed more likely to participatein recycling programs in the United States, at least prior to the recent nationalemphasis on recycling.Age, though generally found to be significantly inversely associated with ecological "concern" and "ecologically responsible" behaviors, apparently is not associated with paper recycling. It appears that recycling appeals not only to young, ecologically-conscious individuals butalso to older individuals who recycle because of traditional values such asfrugality.(4) Humphrey et al. examined the conditions under which university personnel, at least in the mid-1970s, would be receptive to taking part in a pilot paper recycling program, and found that more employees (95.5%) expressed a willingness to participate if provided with two wastebaskets than said they would ifprovided with a divided wastebasket (88.5%) or a centrally located container(53%).(4)

Employees who were encouraged to recycle in a letter from their department supervisors separated their paper more accurately (92.5%) than those who received only a "generic" letter (88%). Finally, those who were sent a written letter from their supervisor and provided with two wastebaskets had the highest quality of paper separation (95.7%). Humphrey et al. found that those who expressed a willingness to cooperate did in fact participate and also indicateda willingness to continue their efforts after the pilot program was over.[4] Conditions that influence recycling within the general community have also been studied. For example, those with less space to store their recyclables have been found to be less likely to continue to participate in a recycling program.[4] Unsurprisingly, limited space has been a greater problem among apartment dwellers than among homeowners . More paper is recycled in the community when collection services are provided on the same day as regular garbage pick-up, at least until the recent dramatic expansion in recycling programs, and in stable communities with an actively supporting citizenry.[4]

The relationship between ecological attitudes and paper recycling has also been examined, as noted, but here too the number of studies is very limited. Borden et al. and Steininger and Voegtlinfound in early studies that those who had higher levels of general ecological concern were significantly more likely to recycle. De Young reported a moderately strong positive relationship existed between general recycling activities and intrinsic motivations related to recycling. Arbuthnot and Linngreported that ecological attitudes were significantly correlated with recycling among Americans, but not among the French, while Arbuthnot found no significant differences in pro-ecological attitudes among general recyclers and non-recyclers. However, general attitudes toward

environment specific attitudes toward paper recycling andintentions to recycle have been found to be significantly related to paper recycling at least in early studies. Other socio-psychological variables positively related to general recycling have included social responsibility, "self-efficacy" , and certain attitudes toward frugality and involvement. In addition, those who reuse their materials and perform other ecologically related behaviors are more likely to recycle. Although general knowledge about ecological issues has not been found to be associated with recycling , more specific knowledgeabout the consequences of recycling has.Finally, inverse relationships have been found to exist between recycling and extrinsic incentives and satisfaction with prosperity. From this review of the literature, it appears that in general people are more likely to recycle their paper when they have convenient recycling opportunities, more formal education, greater incomes, and greater knowledge about recycling.(4)

Furthermore, people who hold positive attitudes toward the environment in general and recycling in particular and perform other ecologically responsible behaviors are also more likely to recycle their paper. Those given monetary incentives are more likely to recycle paper, provided that such incentives are maintained and adequate facilities and service are supplied. All in all, a greater level of participation by the public in paper recycling programs can be expected if such individual, social and institutional factors conducive to paper recyclingoperate in concert.(4)

3. De-inking of waste paper: Flotation:

The earliest work on utilization of froth flotation for de-inking of waste papers dates back to the 1930s. The first flotation de-inking patent was filed by Hines in 1933. However, it was not until 1952 that the first commercial flotation de-inking system was installed at a paper mill in the USA, and the first European installation was at a tissue mill in Greece in 1959. Up to 1970, the growth of flotation de-inking technology was relatively slow. However, in the past 20 years, the market has grown extremely rapidly. The worldwide flotation capacity for de inking of waste papers has increased from 0.2 million tons in 1965 to about25 million tons in 1995.(5)

De-inking is a separation process to remove inks and other non non-fibrous contaminants from wastepapers. Different types of units are required to separate inks from fibers, and this mainly includes washing, flotation, cleaning and screening. The selection and operation of these units are based on the types of wastepapers and the requirements of the finished de-inked pulp. Wastepaper is commonly grouped into five categories, which include mixed paper,old newspapers, old corrugated containers, pulp substitutes and high grade de-inked.(5)

De-inking is a two-stage process which involves dislodging the ink and non-fibrous contaminants from the fiber surface and removing them by washing, flotation, cleaning and screening. Common contaminants include ink, staples, paper clips, sand, plastics and stickies. The most important and widely usedde-inking process to date is the froth flotation process. This process removes the widest range of ink particles from wastepapers.(5)

Flotation alone or in combination with other processes can remove almostall types of ink particles and other contaminants from the slurry of wastepaper.[5]

3.1 Flotation Process and Equipment:

3.1.1 Flotation Process:

Pulping:

The first step in de-inking wastepaper is pulping. Because of the nature of the chemicals and equipment used to pulp wastepaper, the pulping process is analogous to sulRte‘cooking’. Chemicals, together with heat and mechanical energy, are used to detach the ink particles and other contaminants from the fibers in a pulpier. Pulping can be either a batch or continuous process. Newsprint mills typically use continuous pulping at a consistency of 4-8%. Othermills usually use batch pulping at a higher consistencyof 8-18%.[5]

Flotation:

Flotation de-inking is a selective separation process that utilizes the difference of surface physicochemical properties between the ink and fiber. Flotation chemicals are fed to the wastepaper slurry to render the ink particles selectively more hydrophobic and hence to increase the floatability. When the air bubbles are sparged into the flotation cell containing the wastepaper slurry, the ink particles get attached to the air bubbles due to their relatively high hydrophobicity and are floated to the surface of suspension, and the hydrophilic fibers remain in the water phase.[5]

3.1.2 Flotation De-Inking System:

Flotation is traditionally the standard European de-inking system for old newspapers. The stocks or wastepaper slurry after pulping generally go through a soaking stage in a dump chest to swell the fibers and to improve ink detachment from the fiber.[5]

The stock is subsequently aerated at 0.7-1.5% consistency in a series of flotation cells. Typically, six to 10 flotation cells in series (primary flotation) are required for efficient ink removal. The froth from primary flotation is subsequently cleaned in a secondary or recovery stage (usually two cells) to further recover food fibers and to decrease fiber loss. A typical and representative example of a Sotation system is illustrated in **Figure 1**.[5]

Most technical advances made during the past 10 years involved utilization of a combination of flotation and washing stages to remove inks from the more complex wastepaper. The concept of the post flotation system is to add a disperger or kneader between two standard flotation stages. The dispersion or kneading stage further helps the detachment and size reduction of ink and other non fibrous particles, and hence improves the overall flotation performance. Evolution of Flotation Cells Froth flotation is the most widely used separation process in modern paper mills. During the last 10 years, the development of flotation de-inking cells has been pursued more aggressively than the technologies of any other segment of the pulp and paper industry. Initially, Denver flotation cells used in the mineral industry were installed in paper mills. These cells are open, rectangular vats, with mechanical removal of flotation froth by a rotating paddle and mechanical mixing of air and pulp suspension at the bottom. However, these cells are not currently in use.

Although the development of flotation cells for de-inking was less dramatic in the early years, there have been many changes in cell design in the last two decades.(5)

The major driving forces of the evolution of modern flotation cells are the reduction in energy and water consumption, lower footprint space and anincrease in efficiency and capacity. Although many changes in flotation cell design have been made, the improvements in Sotation de-inking performance are not always obvious. More recently, because of the great advances in printing, coating and modiRcationof paper by converters to impart special properties, flotation de-inking has evolved from removing inkparticles only to removing an ever-increasing variety of objectionable, non-cellulosic materials. However, in terms of ink removal efficiency, older flotation cellsperform satisfactorily.(5)

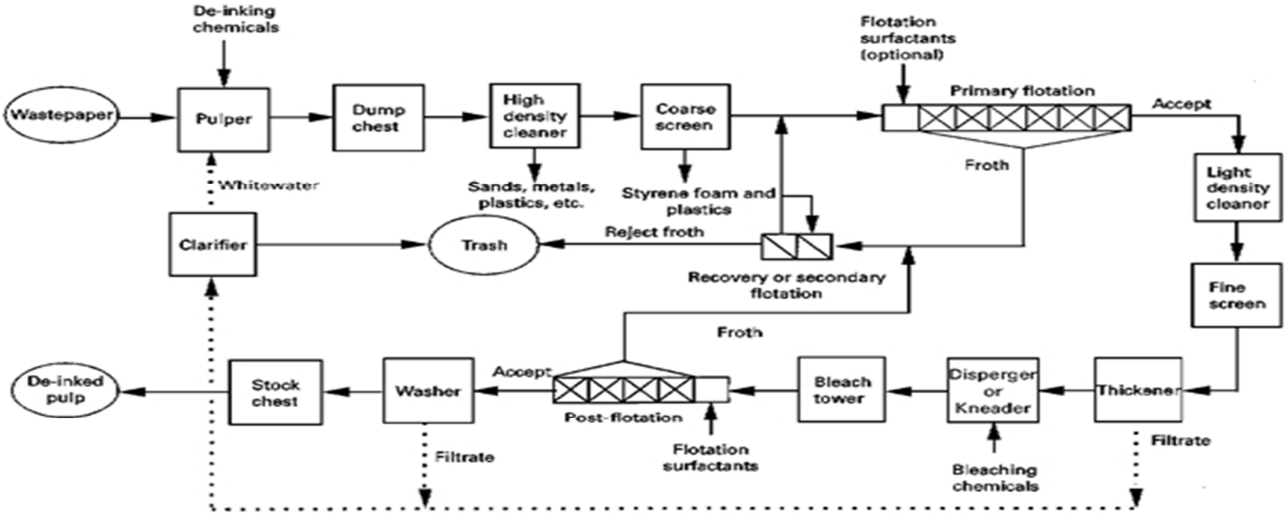
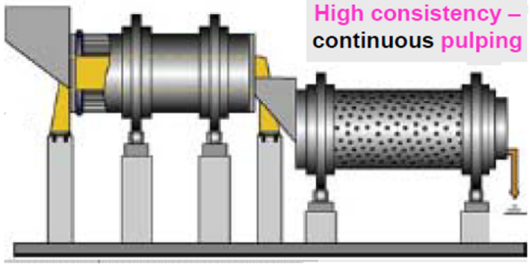


Figure 1 Flow diagram of a typical flotation de-inking mill for mixed paper:

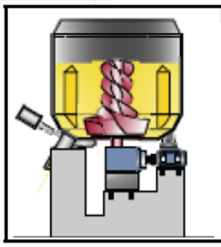
تعجين الورق الخام Pulping

بعثرة الشعيرات و فصل الحبر عن الشعيرات



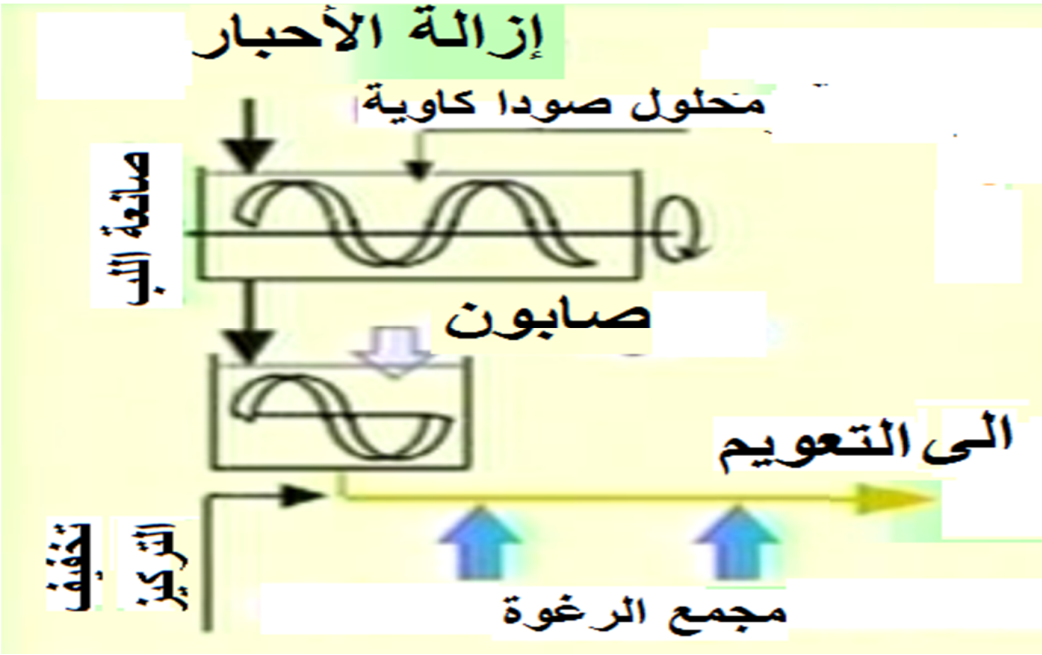
High consistency – continuous pulping

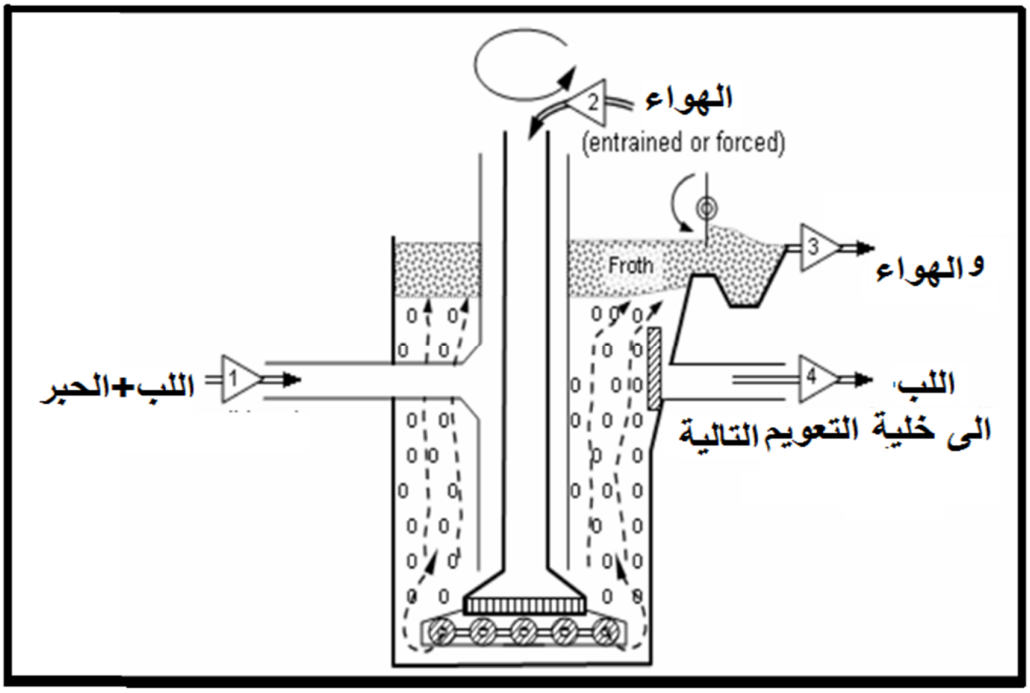
عجينة متسقة و مستمرة الإنتاج

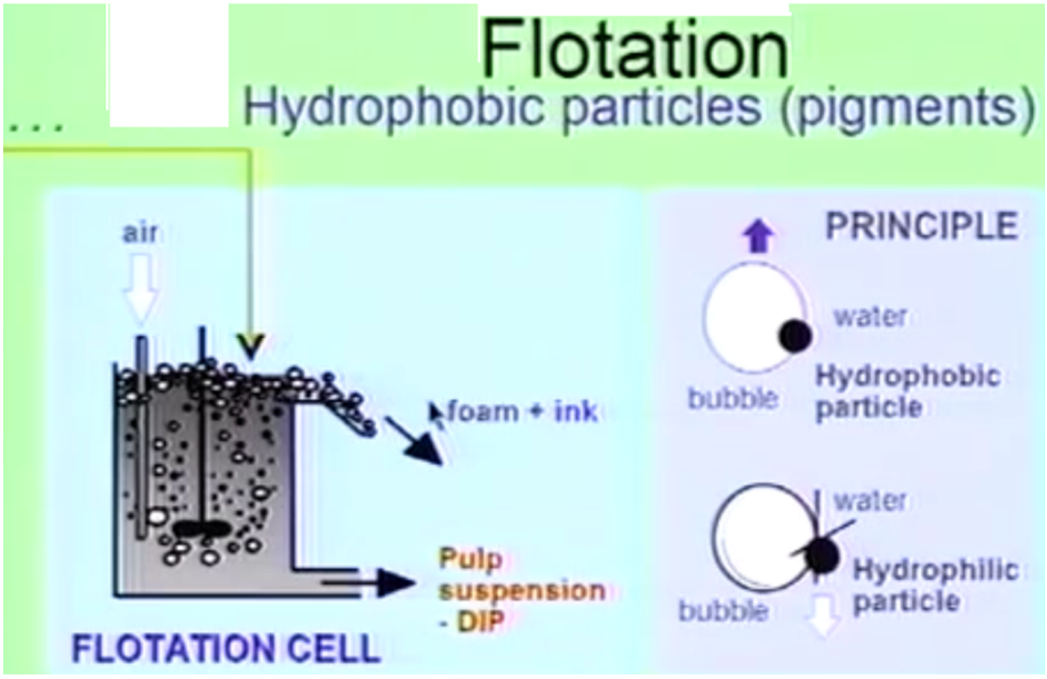


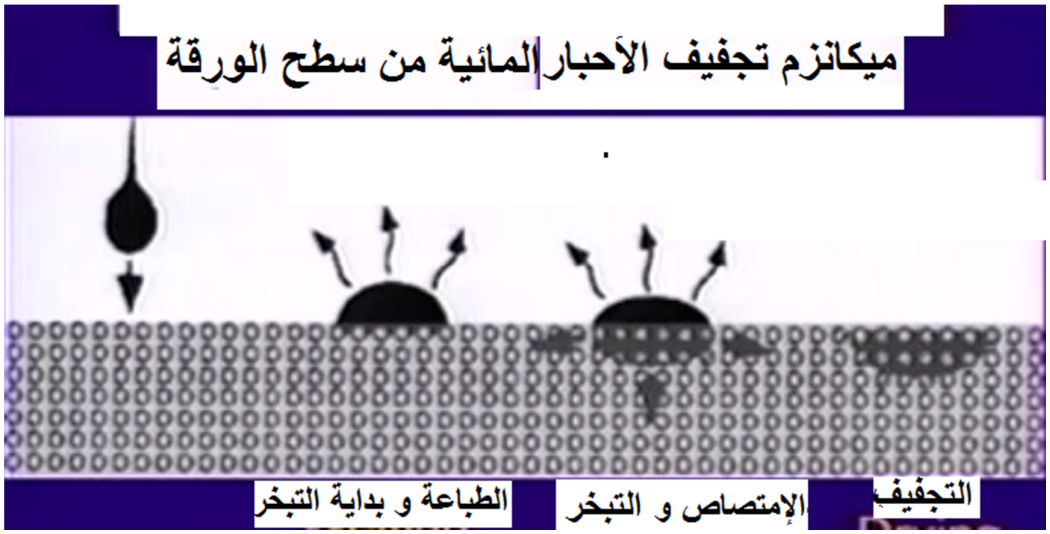
High consistency – batch pulping

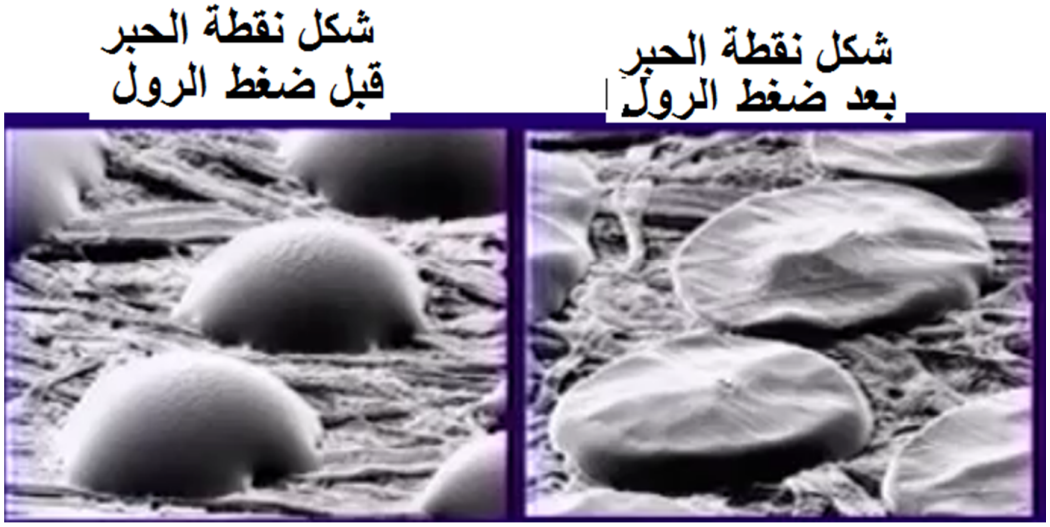
عجينة متسقة بنظام الدفعات




الهواء
2
(entrained or forced)
Froth
3
والهواء
اللب+الحبر
1
4
اللب
الى خلية التعويم التالية


Flotation
Hydrophobic particles (pigments)
air
foam + ink
Pulp suspension - DIP
FLOTATION CELL
PRINCIPLE
water
bubble
Hydrophobic particle
water
bubble
Hydrophilic particle





3.2 Factors Affecting Pulping and Flotation:

The performance of flotation de-inking is affected by many factors such as pH, consistency, temperature, ink/fiber particle size, chemical types, water hardness and air bubble size. Properly controlling these factorsensures the efficient removal of ink.

pH: pH significantly affects both the pulping and flotation processes by altering the physical and chemical properties of fibers and inks. High pH helps swelling of fibers and promotes the detachment of inks from fiber. However, if the pH is too high (e.g. ' 10), it may cause yellowing or darkening of lignin-containing pulps. The conventional fatty acidsand soaps used as ink collectors are only effective atalkaline pHs. Neutral pH flotation de-inking requiresthe use of more effective and selective nonionic surfactants.(5)

Temperature: Pulping and flotation temperaturesare typically maintained at 40-553C and 35-453C,respectively. In general, elevated temperatures areused to improve the de fibrization of special wastepaper such as wet strength paper. Lower temperature is beneficial to high stickies-containing wastepaper,such as magazines.(5)

Consistency: Consistency or dry fiber per cent weight in water has a direct impact on the ink particle size distribution. Depending on the types of wastepaper, different pulping consistencies are used. In newsprint mills, low-consistency (4-8%) pulping is generally used. However, in office paper de-inking mills, medium (8-12%) or high consistency (12-18%) pulping is widely applied. In general, the higher the pulping consistency and the longer thepulping time, the smaller the ink particles liberated.Typical fiber consistency in flotation operation is0.7-1.2%.(5)

Particle size: Flotation is most effective for removingink particles ranging from 10 to 150 m. In general,particles smaller than 10 m and larger than 150 mcannot be efficiently removed by flotation process.(5)

Water hardness: In newsprint flotation, fatty acids or soaps are used as ink collectors, and a moderate amount of calcium ions (100-300 p.p.m.) is required to make the ink floatable. No additional hardness orcalcium ions are added when nonionic surfactants areused.(5)

Ash orfiller content: There is a strong relationship between the amount of clay or fillers in the wastepaper and the ink removed in a flotation stage. Flotation de-inking becomes much more effective when the wastepaper has significant ash content. An 8-10%ash is considered a minimum requirement, and12-14% is preferable.(5)

3.3 Evaluation of Flotation Performance:

Three major parameters are widely used in the paperindustry to characterize the flotation deinking efficiency: brightness, ink removal and reject rate.(5)

Brightness is the percentage of re Sentence measurement of pulp or paper products at a wavelength of457 nm. It is originally developed to evaluate bleaching efficiency. In general, pulp brightness increases asink is removed. The brightness increase is usually inthe order of 10-l5 units for newsprint de-inking and of 5-10 units for white grades.(5) Reject rate is defined as the mass rate of reject to total stock fed into flotation. A main objective of flotation de-inking is to obtain the maximum inkremoval at a minimum reject rate.(5)

For mixed force wastepaper (MOW), reject rate is commonly 10% and for ONP/OMG, it is about 15%. Ink removal is calculated based on the ink concentration of the pulp before and after flotation. Image analysis techniques are used to measure ink particlesize (' 3 m), total counts and the total surface area.(5)

Effective residual ink concentration (ERIC) measurement was developed to determine the visual effect of residual inks on the de-inked pulp. The visual effect is primarily dependent on the presence of small size ink particles (3 m) rather than the total ink content of the paper. To evaluate the de-inking efficiency, both the ink removal of different size particles and brightness should be reported together with reject rate. For newsprint mills, brightness and ERIC measurementsare usually employed and, for white grades, ink countmeasurement is very common.(5)

3.4 De-Inking Chemicals and Recipes:

The use of chemicals is involved in almost every aspect of the key processes in de-inking. Chemistry is of great importance in flotation de-inking in terms of fiber swelling, ink detachment, dispersion, anti-redeposition, ink agglomeration, ink collection and removal. Most of the chemicals used for de-inking are fairly standard commodity products, such as sodium hydroxide and sodium silicate. On the other hand, some other chemicals are relatively complex and have multiple functions. In general, most de-inking chemicals are added in the pulper. Commonly used de-inking chemicals in pulping and flotation, theirfunctions and addition points are listed in Table 3.(5)

Table 3 Chemicals used in flotation de-inking and their functions:

Chemical	Structure/formula	Function	Furnish type	Dosage (% of fiber)	Addition point
Sodium Hydroxide	NaOH	-Fibre swelling -Ink break-up Saponification	All grades	0-5	Pulper
Sodium	Na2SiO3	Inkdispersion-	Groundwoo	0.5-5	Pulper

Silicate		Wetting- -Peroxide stabilization -Alkalinity and buffering	d grades Lightly inked ledger		
Sodium Carbonate	NaCO3	Alkalinity-Buffering -Water softening	Groundwood Grades Lightly inked ledger	0.25-5	Pulper
Hydrogen Peroxide	H2O2	-Prevention of fibre yellowing	Groundwood Grades Coloured ledgers	0.5-2.5	Pulper
Sodium hydrosulfite	Na2S2O4	-Bleach, colour stripping	Coloured Ledgers Coloured ledgers	0.5-1.5	Pulper, Pulp storage
Sodium or potassium phosphate	Hexametaphosphate Tripolyphosphate	-Metal ion sequestrant -Ink dispersion -Alkalinity and bufferingDetergency	All grades	0.2-1	Pulper
Chelating Agents	EDTA DTPA	-Metal ion chelation -Peroxide stabilizer	All grades	0-0.5	Pulper

Calcium Ions	CaCl2	-Fatty acid/soap collector aid	Groundwood grades	90-300 p.p.m.	Flotation Pulper,
Hydrophilic	Polyacrylate	-Ink anti-redeposition	All grades	0.1-0.5	Pulper
Polymers	Carboxymethylcellulose	- Anti-redeposition			
Nonionic	Ethoxylated alcohol	Ink collector-			
Surfactants	Ethoxylated alkyl phenols	-Flotation frother Wetting- -Emulsification	All grades	0.1-2	Pulper Flotation
Fatty acids or soaps	Stearic acid Oleic acid Fatty acid mixtures	-Ink collector -Flotation frother	All grades	0.5-3	Pulper Flotation
Solvents	C1}C14 aliphatic saturated hydrocarbons	-Ink softening -Solvation of wax	Wood-free grades	0.5-2	Pulper

3.4.1 Pulper Chemicals:

The chemicals used in the pulper depend strongly on the types of wastepaper processed. The principal chemicals used for pulping and flotation are sodiumhydroxide, sodium silicate, chelating agents, hydrogen peroxide, surfactants and solvents. The roles ofthese major de-inking chemicals are precisely discussedbelow.[5]

Sodium hydroxide: Sodium hydroxide is used to promote fibre swelling and to saponify or hydrolyze the ink resins by increasing pH and alkalinity. The type and amount of alkali required in the pulperdepend on the type of mechanical treatment, temperature and pulping time. However, the addition of excessive caustic soda to ground wood-

containingfurnishes will cause the pulp to yellow or darken.This is termed as ‘alkali darkening or yellowing’.Sodium carbonate is rarely used in modern de-inkingmills.(5)

Sodium silicate: Sodium silicate or water glass isgroundwood papers. It not only serves as an alkali to swell fibre andas a dispersant of ink particles, but also buffers thepulp to a pH range which is favourable to the actionof hydrogen peroxide.(5)

Hydrogen peroxide: Hydrogen peroxide is one of the most commonly used pulping chemicals in the recycling of groundwoodwastepaper. It is also widely used as a bleaching chemical. The addition of hydrogen peroxide in the pulper is to offset the formation ofchromophores created by high alkaline pH.(5)

Sodium hydrosulfite: Hydrosulfite is mainly used asa reductive bleaching agent to bleach recycled pulpand to decolourize the colouredfibres.(5)

Chelating/sequestering agent: Chelating compounds are commonly added in the pulper to form complexes with multivalent metal ions to prevent peroxide decomposition. Diethylenetriaminepentaacetic acid (DTPA) andethyelenediamine tetra acetic acid (EDTA) are the most common chelates used in the paper recycling industry. Compounds like DTPA andEDTA have been banned in some countries, forexample, Sweden and Norway.(5)

Dispersants: Sodium tripolyphosphate and tetrasodium pyrophosphate are sometimes added to the pulper to provide multiple functions such as ink dispersion and metal chelating. Use of laundering antiredeposition agents such as carboxymethylcellulose and sodium polyacrylate can also

help disperse the ink particles, prevent redeposition of ink on the fibre,and increase de-inked pulp brightness.[5]

Solvents: Organic solvents were once widely usedto dissolve waxes and varnishes, but environmental concern has curtailed the use of these chemicals. Solvents used in wastepaper deinking include C12-C14 hydrocarbons and glycol ethers.[5]

3.4.2 Flotation Chemicals:

Surfactants are probably the most important chemicals in flotation de-inking. They consist of two principal components a hydrophilic component and a hydrophobic component. It is assumed that the hydrophilic end of the molecule attaches to the ink particle, leaving the treated surface state hydrophobic. Most surfactants used in flotation de-inking play two important roles. Firstly, they function as ink collectors that selectively render the ink particle surface more hydrophobic and facilitate ink particle air bubble attachment. Secondly, they serve as flotation frothers that generate moderate foaming. Surfactants used in flotation de-inking can be cationic, anionic, nonionic or amphoteric, and are added either at thepulper or just before the flotation cells.[5] The most frequently used surfactants are fatty acids and their soaps, as well as nonionic surfactants.[5]

Cationic surfactants are not currently used in flotation cells. Commonly used flotationde-inking surfactants and their formulas are shown in **Table 4**.[5]

Table 4 Typical flotation de-inking surfactants

Types	Name	Formula and structure
Anionic	Fatty acid and emulsion- -Fatty acid soap (stearic/palmitic/oleic acid and soap) Alkylbenzenesulfonate- -Fatty alcohol sulfate -Fatty alcohol ether sulfate	$CH_3(CH_2)_nCOOH$ $CH_3(CH_2)_nCOONa$ $CH_3(CH_2)_nCOONa$ $R\text{-}(C_6H_4)\}SO_3Na$ $R\text{-}OSO_3Na$ $R\text{-}O\text{-}(CH_2CH_2O)_nSO_3Na$
Cationic	- Dodecyltrimethylammonium bromide	$CH_3(CH_2)_{12}NH_4Br$
Amphoteric	-Sulfobetaine	$RN^{\#}(CH_3)_2(CH_2)_xSO_3$
Nonionic	Fatty alcohol ethoxylate- -Ethoxylated alkyl phenol -EO/PO copolymers -Fatty acid alkoxylate -Alkyl phosphate ester -Fuel oil -Fatty oil alkyleneoxide derivative	$R\text{-}O\text{-}(CH_2CH_2O)_xH$ $R\text{-}(C_6H_4)\}O\}(CH_2CH_2O)_xH$, n"8-9 $HO\text{-}\ (EO)_x\ \text{-}\ (PO)_y\ \text{-}(EO)_z\ \text{-}H$ $RCOO\text{-}(CH_2CH_2O)_xH$ $(RO(CH_2CH_2O)_n)_2POONa$ $CH_3(CH_2)_nCH_3$

EO, Ethylene oxide; **PO**, propylene oxide.

Fatty acids and soaps: Fatty acids and their soaps are early flotation de-inking surfactants, and are commonly used in Europe than in North America. Mixtures of fatty acids with carbon chain lengths of 16-18, such as stearic, oleic, palmitic and linoleic acids, are commonly used as ink collectors. Saturated fatty acid soaps usually have better ink collection while unsaturated fatty acid soaps have higher foaming. To function effectively as ink collectors, fatty acids require the presence of moderate concentration of calcium ions such as at least 12 degree German hardness (dH) or approximately 200 p.p.m. as calcium carbonate. The calcium ions can be sourced from the paper fillers such as calcium carbonate, orfrom the addition of calcium chloride or oxide. To maximize the function of any source of calcium ions, it is important to maintain the flotation in alkaline conditions (8-8.5), otherwise fatty acids precipitate. However, the presence of excess calcium ions in the system may cause fibre loss.[(5)]

Nonionic surfactants: Nonionic surfactants encompass a large number of synthetic chemicals of varied types and structures. Major types of nonionic surfactants include fatty ethoxylate, alkyl phenol ethoxylate and fatty acid alkoxylate. Cloud point and hydrophilic/lipophilic balance (HLB) value are two important terms used to describe a given nonionic surfactant. Cloud point is the temperature at which nonionic surfactants become separated from the solution. Below the cloud point, surfactant has higher foaming and above the cloud point, the foaming of surfactants decreases dramatically. HLB value is the ratio of weight percentages of hydrophilic to hydrophobic groups in the structure. Generally, for the same surfactant, the higher the HLB value, the higher the foaming ability, and the lower the ink collection ability. An effective nonionic flotation surfactant usually possesses the properties of good ink collection and adequate foaming. Some of the most common nonionic surfactantsused in

flotation deinking are EO/PO copolymers, in which the hydrophilic part is EO (ethylene oxide) and the hydrophobic part is PO (propylene oxide). Alkoxylates of fatty alcohols or fatty acids containing both EO and PO units have been used as flotation surfactants. As environmental regulations become tougher, deinking mills tend to prefer to use surfactants that are easily biodegradable. Because of the difficulty of breaking down alkyl phenols in wastewaters, they are gradually being replaced by readily biodegradableproducts such as alcohol ethoxylates.(5

3.4.3 Flotation recipes:

The selection of optimal flotation chemistry recipes depends strongly on both ink properties and types of wastepaper. The flotation recipes that are commonlyemployed are summarized in **Table 5**.(5)

Table 5 Typical flotation recipes of waste paper de-inking:

Medium	**Pulping**			**Flotation**	
	Alkali and bleaching agent	**Chelate or dispersant**	**pH**	**Collector and frother**	**Furnishes suitable for the flotation chemistry**
Alkaline de-inking	NaOH Na_2SiO_3 H_2O_2	EDTA DTPA Phosphate	8.5-11.5	-Fatty acids or soaps withcalcium ions - Fatty acids or soaps - Fatty acids or soaps and nonionic	-100% ONP, 100% flexographic ONP/OMG- -ONP/OMG, ONP/SOW, OMG -trimming/MOW -ONP/OMG, ONP/SOW, OMG -trimming/MOW -Sorted ledger, MOW, CPO

				surfactants - Nonionic surfactants. -Fuel oil and nonionic - surfactants	-100% flexographic ONP and OMG
Neutral de-inking	NaOH (optional)	EDTA DTPA (optional)	5.5-8.0	-Fatty acids or soaps -Fatty acids or soaps and nonionic surfactants - Nonionic surfactants -Fuel oil and nonionic -surfactants	-MOW, sorted ledger, OMG - trimming/MOW -MOW, sorted ledger,OMG/MOW, CPO, manifold -MOW, sorted ledger,OMG/MOW, toners - Flexographic ONP/OMG

Old newspapers: Newsprint (100%) is often de-inked by washing. However, flotation can also be effective to remove newsprint inks with fatty acid/calcium ion chemistry. In the absence of calcium ions, the ink particles do not float using fatty acid collectors. The addition of calcium is indispensable for a fatty acid or a soap to function properly as a collector. Positively charged calcium ions are bonded to the fatty acid and to the negatively charged ink particles, and thereby promote ink flotation. Calcium ions (often as calcium chloride) should be added to the pulp simultaneouslyor before the fatty acid at a level of above100-150 p.p.m. as calcium carbonate.[(5)]

ONP/OMG mixture: Ash plays a very important role in the flotation de-inking of newsprint. It is a common practice to include a certain per cent of old magazines (OMG) in old newsprint (ONP) for better flotation de-inking efficacy. Since OMG and mixed office waste (MOW) contain fillers such as calcium carbonate, the presence of these fillers in the wastepaper promotes ink flotation. This is because the fillers can provide the calcium ions needed by the fatty acids. Traditionally, the mixtures of ONP and OMG, usually in the ratios of 70 : 30 and 50 : 50, are de-inked by flotation at an alkaline pH using fatty acids or soaps. A significant improvement in ink removal of newsprint can also beachieved by addingclay to the pulper.(5)

Mixed paper: Most of the early plants used alkaline conditions to de-ink mixed wastepaper. However, there is a trend for modern de-inking mills to switch to neutral conditions. Fatty acids are commonly used in Europe and Asia and nonionic surfactants alone are commonly used in North America for de-inking mixed paper. However, fatty acids in combinationwith nonionic surfactants are found to be the mosteffective in removing both large and small ink particles.(5)

Flexographic inks: Flexographic inks are waterbased inks and are difficult to de-ink using flotation due to the hydrophilic nature and very small size (5 m) of the ink particles. Flexographic inks tend to redeposit on the fibres and may cause a dramatic brightness drop of the pulp. Similar to 100% newsprint, fatty acid soaps and calciumions are found tobe effective in removing flexographic inks.(5)

Toner inks: Xeroxgraphic paper and laser computer printout (LCPO) are frequently found in government publications and general office waste. The inks in these papers are thermoplastic powders or toners, and are

firmly bonded to the fibres with a heatfusion printing process. The toner ink particles are hydrophobic, but their removal efficiency by flotation is poor compared with conventional inks since the toner inks are large in size and cannot be sufficiently detached from fibres in the pulper. Effective removal of toner inks can be realized using high consistency mechanical dispersion of the pulp with kneader and disperger followed by flotation using nonionic surfactants. Kneader and disperger assist flotation. by improving toner fibre detachment and by reducing the ink size distribution to a more floatablerange.[5]

4. Classical method :

Papers were cut into small pieces and put in the water for 48 hours .then the pulp was mixed in a mixer . after that the pulp was put in a strainer for water disposal . the pulp then was broached hard to get to the final thickness . the paper exposed to the air until it was dried .

4.1 The result :

a paper has been made in the house with the traditional , classical method .

Table 6 description of the paper:

the length of the paper	22 cm
the width of the paper	17 cm
the weight	28.54 grams

The weight / m^2 = 7.631 g/m^2

4.2. Discussion :

the experiment was made in the house according to a traditional classical method using our hands , which proves that paper recycling is a very simple , easy , safe and cheap and the most importantly it can be made at schools using simple tools which encourages students to involve in funny activities that good for their environment .

the instrumental method that mentioned above including the de-inking process supposed to be made in a specific factory but for unknown reasons the factory has been stopped .

usually such factories face the problem of getting rid of the water waste after the recycling , it could be very dangerous because of its contents from the chemicals , specially if the disposal is made in the seas . the best way to avoid the problem is to do recycling to the water and then it can reused in the recycling paper process .

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