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ECOLOGICAL ENGINEERING

Курс для магистрантов и аспирантов по направлениям подготовки «Техносферная безопасность», «Энерго- и ресурсосберегающие процессы в химической технологии, нефтехимии и биотехнологии»

Учебно-методическое пособие

Санкт-Петербург

2019

МИНИСТЕРСТВО НАУКИ И ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ

«САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ ПРОМЫШЛЕННЫХ ТЕХНОЛОГИЙ И ДИЗАЙНА»

ВЫСШАЯ ШКОЛА ТЕХНОЛОГИИ И ЭНЕРГЕТИКИ

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Учебно-методическое пособие посвящено практическому овладению научной речью в сфере профессионального общения. Предназначено для магистрантов и аспирантов института технологии.

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ОГЛАВЛЕНИЕ

ПРЕДИСЛОВИЕ

Данное учебно-методическое пособие предлагается студентам магистратуры института технологии по направлениям подготовки «Техносферная безопасность», «Энерго- и ресурсосберегающие процессы в химической технологии, нефтехимии и биотехнологии для изучения английского языка.

Основной задачей курса «Английский язык» является обучение практическому владению научной речью в сфере профессионального общения.

Основой построения программы обучения является направление или аспект «язык для специальных целей» (Language for Specific Purposes - LSP). Данный аспект предполагает развитие навыков, необходимых для освоения соответствующего регистра речи.

Целью данного курса является подготовка высококлассного специалиста международного уровня, одной из составляющих в будущей профессиональной деятельности которого станет языковая грамотность и культура речи. Задачи, стоящие перед студентом: закрепление навыков правильного английского произношения (Oxford English); знание особенностей построения научно-технических текстов из оригинальных источников и овладение техникой работы с ними; самостоятельный поиск и извлечение информации на иностранном языке и её дальнейшее применение в профессиональной сфере; умение поддержать и вести беседу с зарубежными специалистами на темы широкого спектра, с учётом различных деловых культур.

В аспекте «Язык для специальных целей» осуществляется: развитие навыков чтения специальной литературы с целью получения информации; знакомство с основами перевода литературы по специальности. Обучение

языку специальности ведется на материале произведений речи на профессиональные темы.

Освоение учащимися фонетики, грамматики, синтаксиса, словообразования, сочетаемости слов, а также активное усвоение наиболее употребительной лексики и фразеологии английского языка происходит не в виде свода правил, а в процессе работы над связными, законченными в смысловом отношении текстами.

Обучение предусматривает: а) формирование фонематического слуха посредством аудирования; б) формирование практических навыков и умений чтения и перевода; в) развитие устной речи; г) отработку грамматического материала с последующим использованием в разговорной речи; д) формирование навыков самостоятельной работы.

В программу самостоятельной работы студентов входит освоение теоретического и практического материала, разобранного вместе с преподавателем на занятиях, подготовка к практическим занятиям в форме словарной работы со статьей, запоминание произношения и написания новых слов и выражений, построение и разучивание диалогов по учебной программе, формирование умений свободно выражать мысли на изучаемом языке, составлять эссе и делать презентацию по заданной теме.

Часть I. ФОНЕТИЧЕСКИЙ КУРС

Английский алфавит

1	A a	[eɪ]	14	N n	[en]
2	B b	[bi:]	15	O o	[əʊ]
3	C c	[si:]	16	P p	[pi:]
4	D d	[di:]	17	Q q	[kju:]
5	E e	[i:]	18	R r	[ɑ:]
6	F f	[ef]	19	S s	[es]
7	G g	[dʒi:]	20	T t	[ti:]
8	H h	[eɪtʃ]	21	U u	[ju:]
9	I i	[aɪ]	22	V v	[vi:]
10	J j	[dʒeɪ]	23	W w	['dʌbl'ju:]
11	K k	[keɪ]	24	X x	[eks]
12	L l	[el]	25	Y y	[waɪ]
13	M m	[em]	26	Z z	[zed]

Чтение окончания -s (-es)

-s читается **[z]** после гласных и звонких согласных:

lives, mills, stands, forms, stays, tries, trees, goes, studies, cars

[s] после глухих согласных:

likes, parents, flats, stops, asks, maps

[ɪz] после шипящих и свистящих звуков [s, z, ʃ, ʧ, ʒ, ʤ]:

sizes, boxes, watches, bridges, colleges, washes, wishes, gases, a'ddresses, pages, uses, branches, classes

Примечание: помните, что окончание -s бывает у существительных и глаголов.

Не следует путать:

- у существительных окончание **-s** – признак *множественного* числа: papers (бумаги, документы), books, students, forms (формы), lights (огни);

- у существительных окончание **-'s** – признак *притяжательного* падежа (отвечает на вопрос **чей?**). Сравните:

my friend	мой друг
my friend**s**	мои друзья
my friend**'s** work	работа моего друга
my friend**s'** work	работа моих друзей

- у глаголов окончание **-s** – признак третьего лица *единственного* числа во времени Present Simple: he (she) reads – он (она) читает, he (she) knows – он (она) знает, he (she) goes – он (она) идёт, he (she, it) lights – он (она, оно) освещает, it snows – идёт снег, he (she, it) influences – он (она, оно) влияет.

Задание 1.1

Прочтите следующие слова:

advises, matches, prizes, sheets, thinks, works, photos, stories, shows, throws, pulps, cooks, rises, 'services, causes, forces, cities, maps, pages, judges, passes, sciences, tries, answers, presses, places, praises, stops, asks, wishes, takes, papers, fibers, chemicals, inches, roots, de'velops, 'surfaces, pro'duces, makes, wastes, 'furnaces, 'purposes, woods, 'processes, 'influences, bags, 'methods, 'differences, 'differs, 'offers, su'ggests, pro'poses, studies, reaches, runs, scientists.

Чтение окончания -ed

-ed читается **[d]** после звонких согласных и гласных:

formed, dried, tried, closed, played, studied, changed, functioned,

contained, used, planned, employed

[t] после глухих согласных:

worked, watched, stopped, helped, liked, stressed, forced,

walked, cooked, pulped

[ɪd] после согласных **t** и **d**:

waited, invited, wanted, decided, visited, de'manded, com'pleted,

su'pported, acted, di'rected, consisted, 'limited, tested, resulted

Задание 1.2

Прочтите следующие слова:

washed, di'vided, de'veloped, burned, im'proved, ab'sorbed, pro'duced, helped, learned, 'regulated, mixed, 'generated, 'operated, pro'vided, liked, in'tended, turned, ex'tracted, com'bined, suited, bleached, 'separated, 'processed, trained, con'verted, solved, missed, di'ssolved, re'mained, in'cluded, heated, produced, po'lluted, 'influenced, manu'factured, con'taminated, changed, looked, littered, a'ttracted, dropped, e'quipped, printed, planted, warmed, lasted.

Часть II. ГРАММАТИЧЕСКИЙ КУРС

ПЕРЕВОД ДВУЧЛЕННЫХ И МНОГОЧЛЕННЫХ АТРИБУТИВНЫХ СЛОВОСОЧЕТАНИЙ, ВЫРАЖЕННЫХ СУЩЕСТВИТЕЛЬНЫМИ ("ЦЕПОЧКИ" СУЩЕСТВИТЕЛЬНЫХ)

Инструкция I. Двучленные или многочленные атрибутивные словосочетания или "цепочки" существительных — это словосочетания, состоящие из существительного и определений, расположенных слева от него.

В качестве левого определения могут быть *существительные* (от двух до пяти или шести). Существительным могут предшествовать: прилагательное, причастие, местоимение или числительное, а также сочетания из этих слов, соединенные дефисом.

Необходимо обратить внимание на то, что внутри такого сочетания *слова не отделены друг от друга ни артиклями, ни предлогами, ни запятыми*:

strong acid pump

white water treatment equipment

high consistency oxygen bleaching system

Для перевода "цепочки" существительных важно найти в ней основное слово. Помните, что *основным словом* любой "цепочки" существительных, является *последнее существительное, с которого и следует начинать анализ* такой "цепочки". Все существительные и другие части речи, стоящие слева от основного слова, являются *определениями* к нему (отвечают на вопрос "какой?", "какие?"). Справа от основного слова, указывая на то, что "цепочка" закончилась, может стоять новый артикль,

предлог, местоимение, прилагательное, причастие или глагол-сказуемое с предшествующим наречием или без него.

I. Перевод двучленных словосочетаний ("цепочки" состоят из двух существительных)

Инструкция 2. Перевод двучленных словосочетаний *начинаем с последнего существительного*, а существительное, стоящее слева, переводится *существительным в родительном падеже.*

Образец:
1) pulp quality - качество целлюлозы;
2) water level - уровень воды;
3) wood consumption - расход древесины;
4) cooking time -продолжительность варки;

a) stock (волокнистая масса) preparation;
stock temperature;
stock production;
sheet properties;
sheet formation (формование).

Инструкция 3."Цепочка", состоящая из двух существительных, первое из которых переводится *прилагательным.*

Образец:
1) wood fiber - древесное волокно;
2) gas bleaching - газовая отбелка;
3) cooking acid - варочная кислота;
4) paper stock - бумажная масса;

wood chips; acid digester; wood species (порода); sulphite digestion; oxygen bleaching; stock pump; laboratory tests; spruce chips; bleaching plant (отдел); hand operation; pine chips; water vapor; cooking process; bag paper.

Инструкция 4. Перевод "цепочки" существительных начинаем с последнего существительного, а первое переводим *существительным с предлогом (в, из, на, для и др.).*

Образец: 1) hardwood pulp - целлюлоза *из* лиственной древесины;
2) drying costs - затраты *на* сушку (затраты, связанные *с* сушкой);
3) pollution control - борьба *с* загрязнением;

digester pressure; softwood pulp; acid (кислая среда) hydrolysis; linen (льняное тряпье) paper; board products; evaporator (испаритель) gases; hard-wood sulphite pulp.

II. Перевод многочленных словосочетаний ("цепочки" существительных состоят из трех и более существительных и других частей речи.)

Инструкция 5. При переводе многочленных словосочетаний рекомендуем:

1) перевести последнее существительное "цепочки";
2) разбить остальную часть словосочетания на *смысловые группы* и перевести их (внутри смысловой группы анализ проводится слева направо);
3) перевести все словосочетание (всю "цепочку"), следуя справа налево.

Образец: 1) stock mixing| *system* – система для смешивания массы;
2) wood fiber| *products* – изделия из древесного волокна;
3) water quality| *results* – результаты по качеству воды;

4) stock preparation| machine *operation* – работа машины по приготовлению массы.

В данных словосочетаниях - по две смысловые группы. Выделено курсивом основное слово.

Переведите, следуя инструкции 5.

a)

chip packing (уплотнение) device;

strong acid pump;

stock preparation machine;

paper machine operation;

fiber suspension flow;

b)

paper formation (формование) time;

chlorine dioxide generation (образование);

pulp preparation operation (процесс);

steam flow rate;

headbox (напорный ящик) control (регулирование) system;

c)

chain (цепь) length distribution (распределение);

fiber length distribution;

chemicals recovery system;

heat transfer (передача) coefficient;

water conservation costs (затраты);

d)

fiber wall thickness;

cooking liquor circulation;

gas diffusion constant;

quality control method;

paperboard test (анализ) result;

e)

plant design changes;

cooking liquor pressure;

stock preparation equipment;

air pollution (загрязнение) problem;

air pollution abatement (уменьшение);

water purity level (степень).

Образец: sodium base| sulfite *pulping*

Sulfite pulping – сульфитная варка;

Sodium base – натриевое основание;

= сульфитная варка на натриевом основании

Переведите, используя образец:

various cooking liquor composition;

high yield sulfite pulp;

constant vapor phase region;

ammonia base sulfite pulping;

caustic soda recovery (регенерация) system;

white water (оборотная вода) treating equipment;

paper mill steam supply (обеспечение);

particle size distribution determination;

calcium base cooking liquor.

Инструкция 6. Если "цепочка" существительных *начинается с прилагательного,* необходимо обратить внимание на то, *к какому слову оно относится.*

Образец: 1) high yield pulp – целлюлоза с высоким выходом;

2) new sheet structure – новая структура листа;

3) maximum cooking temperature – максимальная температура варки.

Инструкция 7. В состав "цепочки" существительных в качестве определения могут входить числительные, местоимения, причастия, существительные в притяжательном падеже и т.д. Обратите внимание, *к какому слову эти определения относятся.* Помните, что *основное слово словосочетания – последнее существительное.*

Образец: 1) this high pressure steam– этот пар высокого давления;

2) rate determining factor – фактор, определяющий скорость.

Инструкция 8. Иногда одно из слов "цепочки" существительных необходимо перевести *поясняющими словами (группой слов).*

Образец: 1) paperboard machine – машина *для выработки картона;*

2) chipping operation – предприятие, *осуществляющее заготовку щепы;*

3) bark products – продукты *переработки коры*.

СТРАДАТЕЛЬНЫЙ ЗАЛОГ ГЛАГОЛОВ
(THE PASSIVE VOICE)

Инструкция 1. Страдательный залог глагола употребляется в том случае, если само *подлежащее не действует*, действие совершается *над ним*.

Глагол-сказуемое в страдательном залоге можно найти в предложении по вспомогательному глаголу ***"to be"*** в соответствующем времени, лице и числе и ***Past Participle*** (причастию прошедшего времени смыслового глагола).

Примечание 1

Past Participle (Participle II) образуется путем прибавления окончания *-ed* к правильным глаголам. Если глагол неправильный, употребляется его *3-я форма* (built, taken, written…). Рекомендуем повторить 3 формы неправильных глаголов.

Примечание 2

Обратите внимание на то, что Past Participle правильных глаголов совпадает по форме со временем Past Simple (produced, achieved). Определить их можно только в контексте. (Подробнее о Past Participle см. в разделе, посвященном причастиям).

Таблица 1

Страдательный (пассивный) залог

Образуется: глагол to be (в соответствующем времени) + Participle II

Правила и способы перевода	Пример	Перевод
1. Страдательный залог показывает, что действие глагола-сказуемого направлено на лицо или предмет, выраженный подлежащим. В ряде случаев подлежащее переводится прямым или косвенным дополнением и ставится, соответственно, в форме винительного или дательного падежа.	**He** was given a task.	**Ему** дали задание.
	We were informed that a new idea had been advanced recently.	**Нас** информировали, что новая идея была выдвинута недавно.
2. Если после глагола в пассиве есть дополнение с предлогом **by** или **with**, то оно указывает, кем или чем производится действие. Предлоги переводятся «путём», «при помощи», «посредством» либо соответствуют творительному падежу и не переводятся.	The calculation is done **by computer programs**.	Подсчёты делаются **компьютерными программами** (**при помощи** компьютерных программ).
	The production line is supplied **with raw material**.	Производственная линия снабжается **сырьём**.

Продолжение табл. 1

Правила и способы перевода	Пример	Перевод
3. Сочетанием глагола «быть» с кратким страдательным причастием с суффиксами -н- или -т-. Глагол «быть» в настоящем времени опускается.	The mill is built by the workers. are built was built were built has been built have been built shall/will be built will be built	Фабрика построена рабочими. построены была построена были построены была построена были построены будет построена будут построены
4. Глаголом на **-ся** в соответствующем времени, лице и числе.	The goods **are being sold** with profit. **were being sold**	Эти товары **продаются** с прибылью. **продавались**
5. Глаголом действительного залога в 3-м лице множественного числа, в неопределённо-личном предложении.	The company's account **is checked**. was checked will be checked	Отчёт компании **проверяют**. проверили будут проверять

Окончание табл. 1

Правила и способы перевода	Пример	Перевод
6. Глаголы с относящимся к ним предлогом, которые переводятся также глаголами с предлогом: to depend on – зависеть от to insist on –настаивать на to look at – смотреть на to rely on – опираться на to speak of (about) – говорить о to refer to – ссылаться на, называть to deal with – иметь дело с и др. переводятся глаголами в неопределённо-личной форме, причём соответствующий русский предлог ставится перед английским подлежащим.	The new plant is much spoken **about**. This article was often referred **to**.	**О** новом заводе много говорят. **На** эту статью часто ссылались.
7. Глаголы без предлогов, которые переводятся глаголами с предлогом: to affect – влиять на to answer – отвечать на to influence – влиять на to follow – следовать за и др. переводятся глаголами в активном залоге или неопределённо-личной форме, причём соответствующий русский предлог ставится перед английским подлежащим.	The conditions of work are greatly affected by the government.	**На** условия работы сильно влияет правительство.

НЕЛИЧНЫЕ ФОРМЫ ГЛАГОЛА
ИНФИНИТИВ (INFINITIVE)

Инфинитив – основная форма глагола, от которой образуются все личные формы глагола во всех группах времен в действительном и страдательном залогах. Инфинитив или неопределенная форма глагола сочетает в себе свойства глагола и существительного.

Признаком инфинитива является частица "to". Она иногда опускается:

после модальных и вспомогательных глаголов; must (can) produce; do not produce; Did the mill produce? Will produce и т.д.

после глаголов физического восприятия: see, hear, feel, watch, notice в объектных инфинитивных оборотах и некоторых других случаях.

Инструкция 1

Повторите формы инфинитива:

Время	Active Voice	Passive Voice
Indefinite – выражает действие, одновременное с действием, выраженным глаголом-сказуемым	to produce	to be produced
Perfect – выражает действие, предшествовавшее действию, выраженному глаголом-сказуемым	to have produced	to have been produced
Continuous – длительный характер действия	to be producing	___
Perfect Continuous – действие началось в прошлом и все еще продолжается	to have been producing	___

Функции инфинитива

Инструкция 2

Помните, что инфинитив *в роли подлежащего* всегда стоит *перед сказуемым* (в начале предложения).

Переводится: 1) существительным;

2) неопределенной формой глагола.

Образец: *To know English* is necessary. – Необходимо *знать* английский. *Знание* английского необходимо.

Инструкция 3

Инфинитив в роли обстоятельства цели отвечает на вопрос "для чего?", "с какой целью?". Стоит либо в начале, перед подлежащим, либо в конце предложения. Может вводиться союзами *so as (to) – с тем, чтобы, in order (to) – для того чтобы.*

Переводится:

1) *неопределенной формой глагола с союзом "чтобы", "для того, чтобы";*
2) *существительным с предлогом "для".*

Образец: *To know* English you should work hard. – *Чтобы знать* английский, вы должны много работать.

Инструкция 4

Инфинитив *в роли обстоятельства следствия* отвечает на вопрос "для чего?" и стоит после слов *too* – слишком, *enough, sufficiently* – достаточно, *sufficient* – достаточный, *very* – очень. *Переводится неопределенной формой глагола с союзом "(для того) чтобы".* Сказуемое при переводе часто имеет *оттенок возможности*.

Образец: 1) I am *too* tired *to go* to the exhibition – Я *слишком* устал, чтобы идти на выставку (чтобы я *мог* пойти…)

2) He is clever *enough to understand* it. – Он *достаточно* умен, чтобы (он *мог*) понять это.

Примечание

В английском языке слово "enough" всегда стоит после прилагательного, но перевод следует *начинать именно с "enough"*, а потом переводить прилагательное: strong enough – достаточно прочный; accurate enough – достаточно точный и т.д.

Инструкция 5

Обратите внимание на *инфинитив в роли определения*. *Он всегда стоит после определяемого существительного* и отвечает на вопрос "какой?". Инфинитив в роли определения чаще всего *имеет форму страдательного залога* и *переводится определительным придаточным предложением*, вводимым союзным словом *"который"*. Сказуемое русского предложения выражает *долженствование, будущее время* или *возможность.*

Образец: 1) The method *to be used – метод, который нужно (можно, будут) использовать.*

2) A beater roll breaks up the material *to be pulped*. – Барабан ролла измельчает сырье, *которое нужно* превратить в массу (*которое будет превращено в массу*).

Инструкция 6

Инфинитив – часть сказуемого. Инфинитив может быть частью: а) простого сказуемого; б) составного именного или в) составного модального сказуемого (=составного глагольного сказуемого) лишь в том

случае, если ему предшествуют глаголы *to be, to have, модальный или вспомогательный глагол.*

Образец:

1) The purpose of the system *is to maximize* production. - Цель этой системы – максимально повысить производительность. Цель системы *состоит в том*, чтобы максимально… Целью системы *является* максимальное повышение…
2) The system *is (has) to maximize* production = The system *must (should) maximize* production. – Эта система должна максимально повысить производительность.

Таблица 2

ПРИЧАСТИЕ

Вид причастия	Функция в предложении и перевод		
	часть сказуемого	определение	обстоятельство
1. Participle I Active voice **selling writing**	He **is selling** his goods. Он **продаёт** свои товары. (Для образования времен группы Continuous. Самостоятельно не переводится).	The merchant **selling** his goods pays a profits tax. Торговец, **продающий** свои товары, платит налог с прибыли. The seller examined the letter **contain-ing** an interesting offer. Продавец изучил письмо, **содержавшее** интересное предложение. (Причастие на -щий, -вший).	(When, while) **selling** his goods, the merchant pays a profits tax. **Продавая** свои товары, торговец платит налог с прибыли. (Деепричастие на -а, -я).
2. Participle I Passive voice **being sold being written**	The goods are **being sold**. Товары **продаются.** (Для образования группы времен Continuous пассивного залога. Самостоятельно не переводится).	The goods **being sold** were foreign made. **Продаваемые** товары были произведены за границей. (Причастие на -емый, -имый).	(**While**) **being moved** the goods are insured against all risks. **Когда** их **перевозят** (**во время перевозки**) товары страхуются против всех рисков. (Придаточное обстоятельственное предложение; существительное с предлогом).

Окончание табл. 2

Вид причастия	Функция в предложении и перевод		
	часть сказуемого	определение	обстоятельство
3. Participle II Passive voice **sold** **written**	1) He **has sold** his goods. Он продал свои товары. (Для образования времен Perfect. Самостоятельно не переводится). 2) The goods **are sold**. Товары проданы. (Для образования пассивного залога. Самостоятельно не переводится).	The goods **sold** gave substantial profit. **Проданные** товары принесли существенную прибыль. The problem **discussed** yesterday is very important. Проблема, **обсуждавшаяся** вчера, очень важна. (Причастие на -щийся, -мый, -ный, -тый, -вшийся).	**If sold**, the goods will give substantial profit. **Если их продать**, товары принесут существенную прибыль. (Обстоятельственное придаточное предложение).
4. Perfect Participle active voice **having sold** **having written**	–	–	**Having sold** his goods he got substantial profits. **Продав** свои товары, он получил существенную прибыль. (Деепричастие на -ив, -ав).
5. Perfect Participle Passive voice **having been sold** **having been written**	–	–	**Having been sold**, the goods gave substantial profit. **После того как товары были проданы**, они принесли существенную прибыль. (Придаточное обстоятельственное предложение).

Таблица 3

ГЕРУНДИЙ

Функция в предложении	Примеры	Перевод
1. Подлежащее	**Chartering** of ships is very important for shipments of goods.	**Фрахтование** кораблей (**фрахтовать** корабли) очень важно для перевозки товаров. (Инфинитив, существительное).
2. Часть сказуемого	The main task is **keeping** customer's accounts.	Главная задача – **хранение** счетов клиентов (**хранить** счета клиентов). (Существительное, инфинитив).
3. Прямое дополнение	The situation requires **controlling** the supply.	Ситуация требует **управлять** (**управления**) поставками. (Инфинитив, существительное).
4. Определение (обычно с предлогом **of, for** после существительного)	The ability **of influencing** the commerce is studied attentively.	Способность **влиять** (**влияния**) на торговлю изучается внимательно. (Существительное, инфинитив).
5. Обстоятельство (обычно с предлогами: **in – при, в то время как,** **on (upon) – по, после,** **after – после,** **before – перед,** **by – творит. падеж,** **instead of – вместо того чтобы,** **for – для** и т.д.	He is able to discuss the terms of an order **without receiving** our special authorization.	Он может обсуждать условия заказа **без получения** (**не получая**) нашего специального разрешения на это. (Существительное с предлогом, деепричастие с отрицанием).

Часть III. ЧТЕНИЕ НАУЧНЫХ СТАТЕЙ

ARTICLE 1

Task 1. Answer the questions:

What do you know about energy crisis?

Is that a global problem?

What solutions do you see?

Task 2. Read the text below.

Climate Change and Energy Management Strategies

(by Elshan Moradkhani)

Abstract

Current climate challenges and energy concerns have urged scientists, researchers, and governments to take action in order to reduce carbon footprint and energy consumption. Considering the growing need for energy supplies, the reliability and sustainability of power plants are another area of concern for communities. Since building is among the major consumers of electricity (almost 40%), the energy management strategies have been substantially focused on demand side management and building operation system. Energy efficiency, peak-load management, and demand response are among the most outstanding and widespread practices in order to reduce building energy consumption and peak demand. Smart grids and smart meters are considerably gaining the attention of policy makers in most developed and developing countries. This paper will revolve around these outstanding energy management strategies and technologies and their merits and drawbacks in the journey of current communities towards sustainability.

Keywords

Smart Meters, Electricity Rate, Smart Grids, Climate Change, Peak Load Management

1. Introduction

Since the Kyoto protocol in 1997 identified global warming as a major issue and recognized anthropomorphic CO_2 as the major contributor, focus has been directed to reduce or eliminate these emissions in order to alleviate climate concerns. A rise in greenhouse Gas (GHG) emissions began with the industrial revolution 250 years ago. Unfortunately, there are increasing releases of GHGs as technology progresses and demand for energy is expanding due to developing economies such as China and India. For example, total primary energy requirement (PER) in China increased from 570 to 3200 Mtce (Megaton of coal equivalent) from 1978 to 2010 for an annual average growth rate of 5.6% per year. This number is estimated to increase up to 6200 Mtce by 2050, while more than 70% of this energy is thought to be supplied by fossil fuels, introducing more CO_2 to the environment. This increasing trend has urged scientist to take action and to apply and create more energy efficient technologies, detect any potential area to increase efficiency in existing systems, and most importantly to identify and target end users consuming highest amount of energy.

Energy crisis is a broad issue that needs governmental action as well as social engagement. Climate change and society are inseparable; human contribution in climate change is undeniable, on the other hand, climate change increasingly affects human welfare. However, researches have shown that societal and individual engagement in global warming mitigation and their knowledge and motivation to do so is extremely limited. Public awareness is not merely enough to press the illness, private individuals need behavioral engagement; people need to understand the cause and consequences of carbon emissions, and should be given the ability to reduce their carbon emission in their everyday life or, in other word, need to be “carbon capable”. Social and lifestyle changes should be addressed all over the communities; governments, industries, commercial sectors, academia, and individuals.

Although social awareness and climate concerns are getting widespread, there are some structural, economic, and social barriers hindering societal engagement. Smart grids and smart buildings have capabilities to create opportunities for consumers to engage in low-carbon lifestyle. They enable policymakers to specify tariffs in a way that they could motivate consumers to cooperate with smart grids and enable both smart grids and consumers to integrate local or centralized renewable energy sources into the electricity network.

The ramification of global changes is not limited to direct effects on human welfare and future life on the planet. It does have some indirect impacts that are less emphasized when referring to global warming. The growing population and developing technologies surprisingly increase demand for energy supplies. Although power plants expansion is inevitable, the commitments to climate change mitigation tends to decrease CO_2 emissions. During peak hours, when electricity demand is maximum, power plants are more distressed to provide electricity for their growing customers. Power outage may occur that is one of the most outstanding indirect impacts of climate change on people's life. Power outage could even happen because of the extreme weather, resulting from human activities, damaging power infrastructures specifically transmission lines. To prevent power outage, while avoiding power plants expansion, communities need either to utilize alternative energy sources like renewable energies or energy storage systems or to reduce consumptions especially during peak hours. Intermittent renewable energy sources are not yet efficient and reliable enough to control energy market. Expensive infrastructures and retrofits are required before RESs extensive implementation. Energy storage, if available, could provide heat or cold for limited hours a day. Energy management and demand response, however, are long-term, reliable solutions for current energy and climatic crisis. The economic and technical barriers in replacing fossil-fueled power plants with RESs shed light on the significance of energy-efficiency, demand reduction, and low-carbon activities. In order for communities to reduce their carbon emissions

and mitigate climate change, to increase overall sustainability and stability, and to decrease climate change impact on human being a stable and reliable power system is required; Smart grids.

It is simplistic to assume that the stability that smart grids may create would not require human intervention and their societal and behavioral adjustment. Smart network include smart buildings and smart users. People, in average, spend more than 90% of their time inside buildings and this dependence makes buildings and human inseparable. One of the greatest building services in HVAC system that is one the largest energy consumers inside building. When Demand Response (DR) occurs in a smart building (manually or automatically) the temporary reduction in building services (lighting level, heating, cooling, and ventilation,) would affect building occupants negatively and would compromise their thermal comfort resulting from a reduction in HAVC services during peak hours. Consumer's motivations to cooperate with smart grid (their concerns for environment, their own and offspring's health and safety, or their budget) or even their denial to cooperate would have an impact on their expectations and behavioral adjustment. The current paper elaborates on different measures and strategies that have been introduced to alleviate climate concerns and manage energy consumption and build power network sustainability as well as their merits and drawbacks.

2. Energy Management

Buildings have been major contributors in current energy crisis and climate challenges. N. Motegi in his paper discusses the different measures that are common in building industry to manage energy consumption, utility bills, and greenhouse gases emissions. Energy efficiency and conservation that mean lowering energy consumption without affecting building services and reduction in unnecessary energy consumption respectively are among the most important practices. These measures are possible through installing energy efficient equipment and operating building efficiently through manipulating building au-

tomation systems (BAS) and control systems. Industrial energy management, since industries consume a substantial amount of energy each day is another growing area of research and development. Industrial refrigerators are other major consumers of electricity. Novel technologies, however, try to replace fossil fuels with renewable energies and recover waste heat to reduce energy consumption. In, an industrial, ammonia-water absorption refrigeration system that consumes solar or geothermal energy or power plants waste heat as energy supply is analyzed and cooling effect (down to 233 K) is studied with 12% higher efficiency relative to similar fossil-fueled system. In another paper she compares this system with a conventional fossil fueled system and a 6% increase in COP was shown through recovering waste heat in expander.

Second practice is peak load management, which includes demand limiting (discharging loads during a pre-defined peak demand) and demand shifting (changing the time of electricity consumption). These practices can be achieved through energy storage systems installation (like cold or heat storage) or by postponing practices like laundry or dish washing to later times like late at night when energy consumption is relatively lower.

The third practice, demand response (DR) shares the same concept with peak- load management; however, DR initiates in response to high electricity price or high demand and grid limited capacity and it takes benefit of real-time pricing and grid reliability data while there is no pre-determined peak-demand. In, DR is defined as “dynamic and event-driven that can be a short-term modification in costumer end-use electric loads in response to dynamic prices and reliability information”. DR will be discussed more in following paragraphs. Figure 1 depicts and compares the demand saving potential of energy efficiency and demand limiting, shedding, and shifting.

3. Smart Grids and Smart Meters

3.1. Definitions

Since information and communication technology (ICT) has given rise to the concept of smart grids and smart meters, the challenge of integrating end users with the grid and maximizing this communication network capabilities in terms of saving energy, demand, and the environment has been under spotlight. The word “smart” is a broad context and when it refers to building or energy system it translates to something that is equipped with advanced technologies and control system, enabling different things to communicate with each other within the network and efficiently respond to internal and external signals. Based on this definition, smart grid is the modernized and revolutionary regime of existing

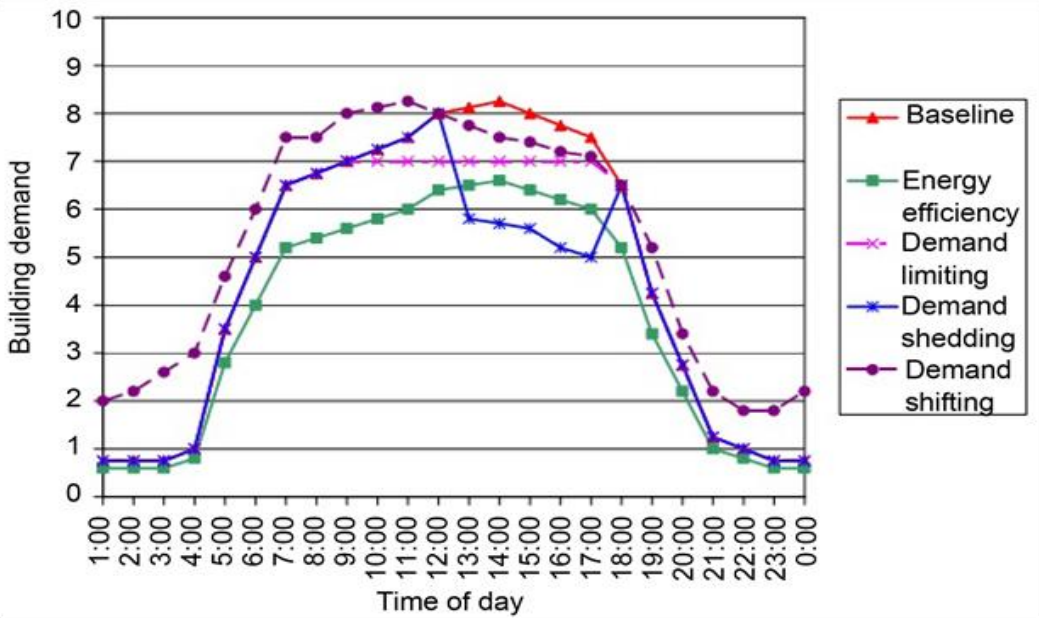

Figure 1. Examples of load shapes, this chart is conceptual; the data are not from actual measurements.

electrical grid that is equipped with information and communication technology to efficiently produce, transmit, and distribute electricity. Its interaction with smart meters within the network improves grid sustainability and stability. Patrick McDaniel defines smart grid as “a network of computers and power infrastructures that monitor and manage energy usage”.

Smart meter system is a bidirectional communication device between smart meter and smart grid that includes smart meter, communication tools, and control devices. Smart meters can read and record real-time consumption data from consumer's premises and securely communicate data. These devices send feedback to power grids and enable them to have secure access to consumption data. Moreover, they enable consumers to receive real-time data including real-time prices and to adjust their consumption pattern. Smart meters are programmable and are equipped with sensors, enabling them to control appliances and other electric devices, turn them off and on when needed, control maximum consumption, and so on. Additionally, smart meter is capable of distinguishing among different power sources and based on the source type (customer-owned energy storage devices or renewable sources, decentralized sources, or power grids) it provides billing information. Smart meters can also communicate with each other if accessible, compete with neighbors in reducing energy consumption, and provide electricity from locale producers if available. The schematic below depicts the differences between manual and smart meters.

Buildings consume approximately 40% of total energy consumption in developed countries and almost half of this energy (20%) associates with HVAC system, providing building occupant's with acceptable thermal comfort. Assuming this large amount of energy dedicated to buildings and occupant's thermal comfort it is almost impossible to have a sustainable community lacking green, smart, and sustainable buildings and HVAC systems integrated to the smart energy network. Smart buildings, through involving in Demand Response (DR) programs could contribute to electricity network sustainability in the community; however, engineers and facility managers should be aware of the ramification of this cooperation on building occupants, specifically their thermal comfort. Since HVAC systems are the major end-users of electricity they have a substantial potential to integrate with DR events. Figure 1 shows a conceptual load distribution during day time.

3.2. Smart Grid Vulnerability

Developed countries such as Germany, UK, US, Canada, and Australia are committed to install smart meters in households in order to manage peak demand and GHG emissions and to increase electricity network security and reliability. Other capabilities are integrating renewable energy sources and even local retailers and electricity producers (prosumers) into the smart grids, smart meters and associated communication technology. However, some drawbacks are limiting consumer's interest and increasing concern over widespread implementation of smart meters. First, installation, replacement, and maintenance of smart meters require billion dollars to be invested. Moreover, there should exist a robust network for all interconnected components and electrical devices (The internet of things) to communicate with each other. This is a sizable challenge for utility companies as well; they need to adjust with ongoing technology and make choices available for customers to cooperate with smart grids. The replacement and maintenance expenses can be decrease by using newly developed SHM methods which replace the scheduled-based maintenance with as-needed maintenance. Guided wave based SHM methods are among these methods which has been extensively researched using different methods such as WSFE-based UEL and the peridynamics. The climate change has some practical implications which limit the predictability of the energy generation. As an example, this fact is more emphasized when using wind turbine energy.

Network systems, rather than demanding a substantial investment for deployment and maintenance, they are prone to malicious cyber and terrorist attack, theft, consumer's misuse of other's data, etc. Smart meters could possibly reveal household's consumption data while communication, data that carry information about occupant's absence or presence at home. Therefore, smart meter struggle with considerable privacy and security challenges while collecting and transmitting data that needs to be eliminated before gaining widespread applications (even though they are already broadly implemented in many countries es-

pecially in Europe). Recent efforts revealed that even existing countermeasure techniques do not eliminate vulnerability issues. It is worth to mention that both power grids and buildings have been prone to cyber-attack even before their interconnection in the form of the internet of things. However, due to the increased points of entries in a heterogeneous network with interconnected devices and their different capabilities, and because of distributed, multi-agent control system in contrast with the hierarchical control system in conventional networks, it is complicated to provide a strong and uniform protection for the entire smart network. Figure 2 provides a comparison between conventional and smart methods of energy metering.

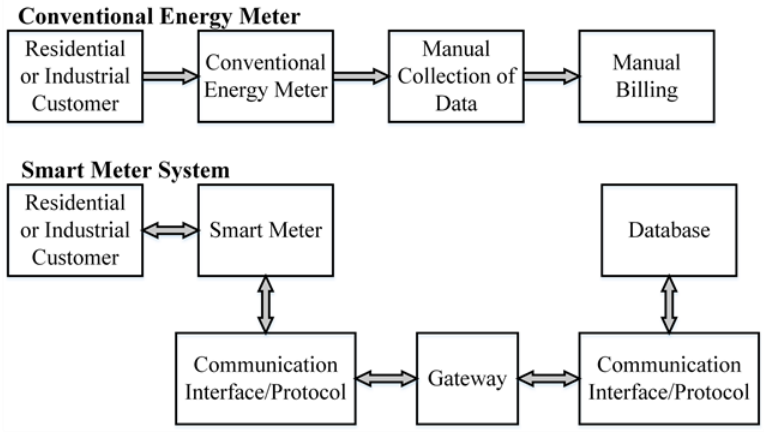

Figure 2. Conventional vs. smart meters

Data storage and transition is another notable challenge for smart meters. Since the storage capacity is always limited, it is important to identify important data to store and the storage time period. Data transition that usually occurs through low bandwidth brings about a heavy traffic making data storage and transition capacity so limited. However, the advantages smart meters offer to the power grids and to their customers outweighs its drawbacks and with lots of engineers and researchers struggling hard to improve the existing prototypes and minimize their deficiencies a brighter future for smart meters in power grids is yet to come.

Nowadays, with an increasing demand to develop a sustainable community, building a reliable energy network is critical since the foundation of a sus-

tainable community lays on a sustainable energy system. A sustainable energy system is the one that allows for interactions between various energy sources, domestic, decentralized, or centralized, renewable, or conventional energy systems. A robust energy system through manipulating GIS (Geographic Information System) is capable of fault detection and could pin point the location of inefficient devices, enabling energy network to prevent losses. A smart meter is a device that helps customers to monitor consumption data for each appliance, control power quality and peak demand, and/or shut the electricity down when consumers exceed the maximum consumption threshold. A smart grid that could distinguish between electricity coming from power grids and those coming from thermal storage or renewable sources could help utility companies in billing their customers based on the real-time data. Soma Shekara in his paper encourages developed countries to replace their conventional power networks with smart grids to overcome their sustainability and peak demand challenges.

4. Dynamic and Time-Dependent Electricity Rate

At the beginning of 20th century, California encountered a severe electricity capacity shortage in a part resulting from inappropriate link between wholesale and retail market and lack of engagement in real-time demand response by retail market. Since then, both in California and across the United States the energy policy shifted towards enhancing real-time demand response to the dynamic electricity pricing through a robust real-time link between wholesale and retail market in residential and commercial sectors. The Energy Policy Act of 2005 urges all the facilities and technologies nationwide to be available for electricity customers enabling them to participate in demand response practices and to adjust themselves with volatile, real time electricity pricing system.

Direct Load Control (DLC) program and Time of Use (TOU) tariffs are being applied for years in residential building as two major tariffs in order to reduce peak demand. DLC programs offers billing credits in exchange of large end- users consumption control and management. This program is usually active

during summer and its major targets are central HVAC systems. A major practice of DLC is increasing thermostat setpoint up to usually 4˚F or turning HVAC systems on and off in varying increments during hot summer days. DLC is easy for customers to apply it with existing technologies, however, it is not a time-based practice and it cannot be helpful during special events and emergency times.

TOU or time of use program allocates higher electricity prices for weekday afternoons. Therefore, a constant time dependent schedule helps power system reliability through decreasing peak-hours consumption and shifting usage to the off-peak hours. However, it does not support a dynamic, real-time, and event driven tariff applicable to emergencies when power system works near or with full capacity.

Although TOU tariffs have been successful in improving power grids reliability and demand reduction, their participation in on-peak reduction is typically around 5%. The tendency for considerable peak-demand reduction in North America and securing grids reliability especially on event driven basis has drawn attentions towards dynamic pricing such as Critical Peak Pricing (CPP) and Real Time Pricing program (RTP) program.

CPP shares the same principal as TOU tariffs; however, these tariffs are applied only to limited special events where high demand is predicted in advance. Real-Time price, however, mirrors real-time production cost of electricity in the market. Thus, the electricity rate varies hourly and price vs. time of the day profile changes on a daily basis. The electricity price in not known until approximately twenty four to one hour beforehand and in contrast to above mentioned tariffs there is no predetermined ¢/kW available. RTP have been considerably successful in saving demand and money in large commercial and industrial firms, nevertheless, RTP implementation is so confusing and troublesome for small households so that it is not usually applied for household applications, instead, CPP is a more common measure for residential purposes.

5. Demand Response

5.1. Definitions

"Demand response (DR) is a set of time dependent program activities and tariffs that seek to reduce electricity use or shift the usage to another time period"; in other words DR is a set of consumers actions, either voluntarily or impulsively, in order to flatten the demand profile, reduce consumption during peak hours, and enhance grid security and reliability. Demand response enables control system that is linked with a smart grid to reduce or delay electricity consumption in peak hours. Since peak-demand is coupled with peak pricing, demand response would help consumers in decreasing their electricity bills (cost reduction) and would contribute to a more reliable and sustainable electric grid. Demand response has a similar policy to energy efficiency, however, when- ever demand response does not affect building services and occupant's comfort it should be considered a "permanent energy efficiency opportunity". Unlike energy efficiency measures, that are part of normal building operation, DR has dynamic characteristics and takes place in response to smart grid signals as a temporary reduction in service. These signals are in form of phone calls, text messages, or emails for manual and semi-automated DR and in the form of direct signals from smart grids to equipment and control system in fully automated DR. DR is applicable both manually and automatically or as a mixture of two that is called semi-automated DR.

5.2. HVAC-Based Demand Response

In cooling seasons when outside air temperature goes up, the demand for HVAC systems is maximum and this is synchronized with maximum electric rate (peak hours). A demand response program is capable to reduce energy consumption, utility bills, and peak demand at peak hours. In, the primary goal of HVAC- based DR is discussed to minimize peak demand while minimizing negative effects of building occupants. He proposes that there are two major strategies to meet these goals: "Global temperature adjustment of zones, or sys-

tematic adjustment to the air distribution system and/or cooling system", while the first strategy better guarantees DR goals. Each building differs in DR strategies depending on building design and application, climate condition, mechanical equipment, building automation system, and building control and energy management policies. It is impossible to precisely predict the DR saving potential due to its correlation with dynamic outside air pattern and unpredictable energy demand.

(Moradkhani, E. (2017) Climate Change and Energy Management Strategies. *Computational Water, Energy, and Environmental Engineering*, **6**, 143-153. doi: 10.4236/cweee.2017.62011.)

Task 3. Summarize all the ideas of the article and write an essay.

Task 4. Make a presentation based on the article.

ARTICLE 2

Task 1. Answer the questions:

What treatment technologies for the pulp and paper industry are used nowadays?

What treatment technologies can you offer to use in the future?

What are the solutions for industrial effluents?

Task 2. Read the text below.

Additive and additive-free treatment technologies for pulp and paper mill effluents: Advances, challenges and opportunities.

(by Mohammadreza Kamali, Seyedeh AzadehAlavi-Borazjani, Zahra Khodaparast, Mohammadreza Khalaj, Akram Jahanshahi, Elisabete Costa, IsabelCapela)

Abstract

In the present manuscript, novel effluent treatment processes for pulp and paper mill effluents are divided into two categories: a) those involving the use of chemical additives and b) those which are free of such chemicals. It is especially of high importance for pulp and paper industry to adopt the most efficient and cost-effective treatment methods. This paper critically reviews the recent studies on the treatment of pulp and paper mill effluents while providing suggestions for further studies on the application of various physic-chemical and biological methods for the treatment of such complex effluents containing a number of re-calcitrant pollutants.

Keywords

Pulp and paper industry, Industrial effluents, Chemical additives, Non-additive treatment processes

1. Introduction

It is well known that the effluents from pulp and paper mills (PPMs) are highly polluted by various types of recalcitrant organic pollutants such as ad-

sorbable organic halides (AOXs), as well as inorganic chemicals normally added during the process of producing pulp and/or paper. However, the amount of pollutants loaded to the final effluents is highly dependent on various parameters such as the type and the stage of the manufacturing process and the type of the raw materials used for the production of pulp and/or paper. Due to this fact, there is a need for treatment methods which are efficient enough, while being both cost-effective and environmentally friendly. It is also of high importance to emphasize that the effluents treatment technology to be adopted by the industry must have the ability to be easily transferred from lab-scale installations to full-scale applications. This is one of the most important issues that must be taken into consideration because a number of methods developed so far for the removal/degradation of recalcitrant compounds were used in lab-scale experiments but with a limited number of evidences for a rapid transferring of the newly developed techniques to real-scale applications. There are a number of barriers for the commercialization of the novel wastewater treatment technologies. The expertise and financial supports required (for instance in terms of the initial investments), the insufficiency of the regulations especially in the developing countries which are not able to force complying with the scientific-based environmental standards, and the treatment costs associated with the application of advanced treatment methods are among the most important barriers. Although European Commission has described the best available technologies to be adopted in large scale applications by pulp and paper mill industry, there is still a need for the industry to continue the collaborations with the researchers to prove and implement new emerging technologies for higher water quality standards. This paper aims to explain the role of chemical additives in wastewater treatment, and also to address the chemical free methods, specifically for the treatment of the P&P mill effluents. The novel treatment methods which have been developed very recently, have also been critically reviewed based on their

individual role and their cumulative effects when combined with biological or other physical-chemical methods.

2. Novel P&P mill wastewater treatments

As stated before, it is of high importance to evaluate each treatment method according to several criteria including their treatment efficiency, their subsequent environmental drawbacks and also the economic issues attributed to the treatment method under consideration. Accordingly, this section has been divided into three main topics involving methods with the application of chemical additives (Section 2.1), non-additive methods (Section 2.2) and a combination of both mentioned treatment methods (Section 2.3) to deal with the effluents from pulp and paper mill industries.

2.1. Additive-based treatment methods

The addition of various chemicals (such as coagulants, oxidation agents, etc.) has been developed as a promising way to treat highly polluted and complex effluents. This section considers the recently developed methods based either on the addition of a single chemical, or those relying on the addition of multiple chemical compounds for the treatment of pulp and paper mill effluents. Considering that the sustainable development of the treatment methods are highly related to both the efficiency of the applied method and also to the probable subsequent toxic effects of the chemical additives, such features have been highlighted in this section.

2.1.1. Single-additive treatment methods

The addition of a single chemical to the content of the pulp and paper mill effluents is the basis of conventional treatment methods such as adsorption, flocculation and coagulation, oxidation, etc. However, recent published papers have mainly focused on the adsorption and oxidation when just a single strategy is desired for the treatment of pulp and paper mill effluents.

Adsorption has been demonstrated as an efficient method for the treatment of various types of wastewaters due to numerous advantages such as simplicity in design as well as cost-effectiveness in terms of initial investment and land requirements. In order to remove both color and organic/inorganic contaminants from pulp and paper mill wastewater, various adsorbents including activated carbon, silica, fuller's earth, coal ash, bentonite, etc. have been applied. Among the existing adsorbents, it has been reported in the literature that activated carbons can offer a higher adsorption performance due to its specific characteristics such as high specific surface area, large pore volume, high-speed kinetic, and coarse texture. However, drawbacks such as being expensive and the need for costly and time-consuming measures to remove the molecules adsorbed inside the pores have stimulate the search to explore substitutes that are available, with low-cost, are reusable and ease of application.

Over the recent years, the performance of various adsorbents has been tested in order to remove dyes and other pollutants from PPMW. Sajab et al. studied the effects of oil palm empty fruit bunch (EFB) fibers modified with cationic polyethylenimine on the removal of colour and organic pollutants from bleaching P&P effluents originated from two treatment stages: primary clarifier and biological aeration tank, named as A and B effluents, respectively. Their experimental results indicated that by increasing the adsorbent dosage, colour and biological oxygen demand (BOD) were significantly reduced in both A and B effluents. For the adsorbent dosage of 9 g/L, there was a BOD_5 reduction of approximately 32.3% and 90.4% in A and B effluents, respectively. Moreover, the maximum colour removal was reported to be 93.6% and 87.5%, respectively, although total organic carbon (TOC) was only slightly reduced. It should be also noted that in their study, an inverse relationship was observed between pH and colour and TOC removals.

As discussed by Kamali et al. some effluents, especially those from *Eucalyptus*sp. pulp and paper making processes, may contain relatively

high amounts of phosphorus. In this case, cost effective methods are also required to treat such effluents preventing their discharge to the environment. Among the recent studies for the removal of phosphorus from the effluents, Barbosa et al. suggested the application of ashes (both fly and bottom ashes), because of their high phosphorus adsorption capacity and their low cost. By addition of fly ash or bottom ash to a P&P mill wastewater (solid/liquid ratio = 34.45 g/L for fly ash and 46.59 g/L for bottom ash) more than 90% of the phosphorus removal was achieved. Ecotoxicological studies using two organisms including *Vibrio fischeri* and *Artemia* franciscana also indicated that there was no acute toxic effects of the supernatant effluents resulting from treated P&P mill wastewater using this method. Although there are some reports in the literature on the application of ashes from various origins for the treatment of different effluents, as a single treatment additive, the number of published works on the treatment of effluents from P&P mills using these materials is rare. It is worthy to note that this technique can provide an opportunity to deal with highly polluted effluents such as those from P&P mills, especially those from bleaching stages.

Providing adequate nitrogen sources for the microorganisms has also been an issue for conventional wastewater treatment plants using biological processes. So, exploring proper nitrogen sources as an additive to enhance the microbial activities would be a need for most wastewater treatment practices. Blank et al. applied a tertiary treatment by controlling the algal growth inside a photobioreactor. They indicated chitin as a good alternative source of nitrogen for the treatment of P&P mill wastewater using algae. Their results showed that algae and cyanobacteria can grow well in the presence of chitin, and they can uptake and remove the phosphorus from the effluent.

The application of wastes from treatment plants for the treatment of industrial effluents can be an attractive candidate, especially in terms of economic considerations. As an example, a batch adsorption system was developed

by Khan et al. in which the inactivated secondary excess sludge obtained from the treatment of P&P mill effluent was utilized as an adsorbent to remove three major phytosterols: ß-sitosterol, ß-sitostanol and campesterol during secondary PPMW treatment. In their study, increasing the concentration of inactivated secondary excess sludge from 20 to 2000 mg/L caused more than 80% reduction in liquid-phase sterol concentration during the first 2–4 h. Moreover, following the same trend, all the three mentioned plant sterols were easily adsorbed onto the inactivated sludge.

Surface area is a main characteristic for an adsorbent as it may determine its available active surface sites to adsorb the targeted pollutants. Hence, the interest of very recent studies has also been to maximize the surface area of the adsorbents. Boonpoke examined the effectiveness of adsorption method using water hyacinth based-activated carbon with high surface area (1066 m^2/g) in both batch and continuous experiments for PPMW treatment. Within the first 40 min, chemical oxygen demand (COD) and colour were removed rapidly. The highest removal efficiency for COD and colour (91.70% and 92.62%, respectively) was observed under continuous mode. Furthermore, it can be an area for further studies to develop adsorbents with very high specific surface area using some novel techniques in the preparation of these materials e.g., ultrasonic irradiation in order to prepare adsorbents with both high surface area and high adsorption capacity.

The use of ion exchange resins for adsorbing harmful contaminants from P&P mill effluents has also became recently of interest to industries. In this regard, polystyrene spheres (PSs) have been extensively applied as a matrix substance due to its advantages such as cheapness, availability and high mechanical stability. However, the cationic or anionic groups on the surface of conventional ion exchange resins are of short-molecular chains. In order to overcome this problem, Xiao et al. through the application of modifications to the spheres surface with a fibrous polymer, intended to study the efficiency of

cationic polystyrene spheres for the removal of anionic contaminants from paper-making white water. The process started with the acylation of PS spheres by acryloyl chloride. Then, poly methacryloxyethyl-trimethyl ammonium chloride (PMAC) was grafted onto cationic PSs spheres using surface-initiated free-radicalpolymerization approach. The effect of temperature and reaction time on the removal of dissolved and colloidal substances (DCS) was then investigated in the cationic PSs concentration of 10 g/L. Their results showed that the adsorption performance of cationic PSs can be improved by increasing the temperature due to raising the molecular motion in the system. Furthermore, at longer reaction times, more DCS could be adsorbed onto the surface of cationic polystyrene spheres. Finally, the obtained cationic PSs spheres indicated the high reusability feature which can be considered as a cost-effective adsorbent for reducing the DCS from the white water.

Reusability studies have also been addressed in very recent studies. Mixing adsorbent materials such as biochar, organobentonite and activated carbon with zero-valent iron (ZVI) particles was found to be a beneficial way for separating the adsorbate from the adsorbent, which resulted in the increase of the adsorbent life time. In addition, it has been reported in the literature that doping adsorbents with another compound can enhance their overall efficiency. For instance, doping with some metal catalyst like nickel can enhance the dechlorination rate of pentachlorophenol (PCP) by zero-valent iron magnetic biochar composites (ZVI-MBC). The removal efficiency of Ni-ZVI-MBC for the PCP removal from the synthetic and real PPMW was evaluated by Devi and Saroha. They reported that Ni-ZVI-MBC is the most efficient compound among the studied materials (97.5% in 60 min). However, the application of advanced adsorbents such as biopolymers and advanced nanomaterials can be recommended for further studies in order to develop effective and cost-benefit methods to deal with highly polluted and complex wastewaters from P&P industry.

There are several reports in the literature on the application of oxidation processes for the treatment of PPMW effluents. However, it can be stated that the full-scale implementation of the most conventional oxidation methods is not economically feasible due to high energy and chemicals requirements for the complete degradation of recalcitrant compounds. Hence, advanced oxidation processes (AOPs) which are able to convert the recalcitrant compounds into more biodegradable substances are considered as a promising alternative within the existing techniques of the PPMW treatment. Among the various AOPs, ozone (e.g., as O_3/UV or O_3/H_2O_2), Fenton's process (H_2O_2/Fe^{+2}), photo-Fenton reactions ($UV/H_2O_2/Fe^{+2}$), and UV radiation together with hydrogen peroxide(UV/H_2O_2) were found to have good performances for removing the recalcitrant contaminants from P&P mill effluents. In general, according to the results obtained from the relevant studies, ozonation with a COD removal of approximately 40% has been successfully implemented at industrial scale, mainly due to the presence of these type of facilities previously allocated for pulp bleaching in some paper mills, whereas Fenton processes with a better efficiency for COD removal (approximately 65–75%) at a laboratory scale, can be considered an opportunity for further developments in order to be used at large-scale applications.

Some recent studies have also been successfully applied, using nano-scale catalysts for the wet oxidation (WO) of PPMW. For example, Anushree et al. investigated the catalytic wet air oxidation (CWAO) of PPMW by NiO-CeO_2 nano-catalysts, prepared via a co-precipitation process. The results showed 62% and 75% of COD and colour removals, respectively, at the mild operational conditions of 90°C and 1 atm. These results can be considered as a proof for the effectiveness of nanomaterials (such as $Ce_{40}Ni_{60}$ nano-catalyst) for the oxidation of non-biodegradable compounds, due to their low size, high surface area and pore size and volume. Anushree et al. applied the synthesized mesoporous $Ce_{1-x}Fe_xO_2$ mixed oxides as heterogeneous catalysts for CWAO of paper mill

wastewater. Under optimal conditions (temperature 90 °C, pressure 1 atm, catalyst dosage 1 g/L, pH = 4, and reaction time of 2 h), $Ce_{0.4}Fe_{0.6}O_2$ mixed oxides revealed optimum COD and colour removals (74% and 82%, respectively). In addition, examining the possibility of catalyst recovery and reuse exhibited that $Ce_{0.4}Fe_{0.6}O_2$ can be applied for three times without a significant reduction in catalytic performance. Non-catalytic wet oxidation methods have also been wider applied compared to CWAO approach due to its both operational simplicity and low cost. In a study of a non-catalytic WO process, Dudala et al. obtained COD and color reductions of 55% and 70%, respectively, from synthetic pulping liquor. The reaction was performed for 4 h at 170 °C and 0.37 MPa of pressure. At the end of the oxidation process, the biodegradability of the wastewater was increased from 0.22 to 0.66. From these results, it may be inferred that the non-catalytic wet oxidation process can also present an acceptable efficiency to reduce contaminants from PPMW.

Combination of oxidation processes and electricity is another option to maximize the treatment efficiency of the pulp and paper mill effluents. Amongst the electrochemical advanced oxidation processes (EAOPs), anodic oxidation (AO) method has attracted a great attention over recent years for reducing toxic and recalcitrant compounds from highly polluted and complex wastewaters. In this process, highly reactive hydroxyl radicals (•OH) are generated at the anode surface (M), according to Eq. (1).

$$M + H_2O \rightarrow M(\bullet OH) + H^+ + e^- \quad (1)$$

Anodic oxidation process is an environmentally friendly technique in which various materials such as platinum, graphite, doped and undoped PbO_2, boron-doped diamond electrodes (BDDs), etc. can be used as anodes. In this respect, Salazar et al. treated raw acid and alkaline bleaching effluents from a hardwood-based Kraft pulp mill by AO-H_2O_2 process containing an air-diffusion cathode and a DSA-RuO_2 or BDD anode at constant cell voltage (2–12 V). In their study, BDD anode showed a much better performance in

the mineralization of the recalcitrant organic compounds when compared to DSA-RuO_2 anode after 9 h, enhancing TOC removal by 75% and 65% from alkaline and acid effluents, respectively. This can be explained by the higher oxidizing capability of its physisorbed $^{\bullet}OH$ and its more inert surface. Three dimensional electrode reactors are another possible solution in this regard. Jing et al. used a novel three-dimensional electrode reactor for the degradation of acidified reed pulp black liquor (Fig. 1). Both types of direct electrolysis based on anodic oxidation and indirect electrolysis based on microcell mechanism revealed a TOC removal percentage of approximately 35.57%. It should be concluded that the three-dimensional electrode systems can be successfully applied for the degradation of PPMW due to their high specific surface area, low energy requirement and high mass transfer when compared to the traditional two-dimensional electrode systems.

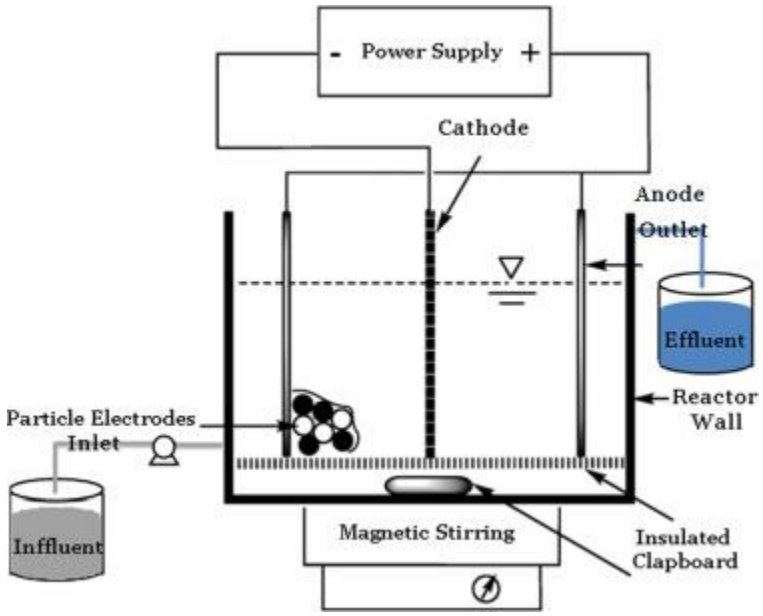

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Fig. 1. A schematic of a three-dimensional electrode reactor, adapted from Jing et al.

The application of polysilicate composite coagulants, as newly developed inorganic polymer coagulants based on poly-silicic acid (PS) and metal salts, has attracted great attention in the wastewater treatment field, due to their distinctive

capabilities for charge neutralization, as well as for adsorption and coagulation of colloidal particles. In this regard, He et al. prepared a poly-silicic-cation coagulant with different Si/(Al+Fe) molar ratios through synchronous polymerization, for the tertiary treatment of recycled paper mill wastewater. In this study, the polymeric aluminum chloride (PAC) was used as benchmark with respect due to its high-quality coagulant ability. The results clearly showed a lower cost as well as an excellent performance of the new poly-silicic-cation coagulant for the removal of COD, colour and turbidity (67%, 95%, and 99%, respectively) from the pulp and paper mill effluents when compared with the traditional PAC treatment.

2.1.2. Multiple additive treatment methods

The application of a combination of two or more single additives is another opportunity to enhance the treatment efficiency of the pulp and paper mill effluents due to the synergic effects of the individual additives on the removal of recalcitrant organic pollutants. However, the number of the combined additive methods is relatively rare in the literature for the treatment of pulp and paper mill effluents. Sticky contaminants is a prevalent problem in mills producing pulp and paper from recycled fibers which can lead to serious consequences on the paper machine, on the production downtime due to the increase in the proceedings related to the maintenance, cleaning, replacing of equipment, etc., and on the increase of the production wastes. Liu et al. evaluated the use of a bentonite & polyacrylamide (PAM) particle flocculation system for the treatment of recycled fiber PPMW. Under the optimal conditions (bentonite dosage: 150 mg/L, PAM dosage: 10 mg/L, pH: 6.4, temperature: 60 °C), 91.26%, 90%, 99.56%, and 95.58% of methyl-tert-butyl ether (MTBE) extract, COD, turbidity and suspended solids (SS), respectively, were removed. Additionally, the average particle size after treatment was reduced from 40.95 μm to 0.5 μm. Therefore, the bentonite adsorption and coagulation treatments were found to be efficient for recycled fiber pulp wastewater treatment, particularly due to its high

capacity for the removal of large size particles and suspended colloidal substances like stickies from PPMW. There are also recent reports on the application of industrial wastes for the treatment of industrial effluents. For instance, Yang et al. prepared an inorganic polymeric ferric aluminum sulfate chloride (PFASC) composite coagulant using waste pickling liquor from steel mills together with polyacrylamide (PAM) in a tertiary treatment. They removed COD and chroma 65.3% and 71.2% respectively, under initial pH 7.5, 1 mL/L PFASC, 1.0 ppm PAM. Very recently, the application of combined additive systems using advanced oxidation processes have also gained a huge attention. For instance, Gopalakrishnan et al. used solar/Fe^{2+}/TiO_2/H_2O_2 process for the treatment of pulp and paper wastewater and found a maximum COD and colour removals of 98% and 97% respectively at optimum conditions of flow rate = 75 mL/min, liquid depth = 5 cm and residence time = 75 min. AOPs using Fenton reactions have also demonstrated good performance with other physic-chemical methods. Grötzner et al. achieved 95% for TOC, 61% for COD, and 76% for lignin contents removals using a sequence of coagulation-flocculation-sedimentation and AOP by Fenton process for the treatment of chemical thermal mechanical pulping effluents from a Brazilian pulp and paper industry.

As a conclusion, it seems that there is room for further studies and developments in the application of combined low-cost and high efficiency chemical additives. Meanwhile, studies on the toxic effects and the relevant environmental drawbacks and life cycle assessment of the combined additives would be essential to promote the full-scale application of such methods.

2.2. Non-additive treatment method

This section aims to review the very recent advances in the treatment of P&P mill effluents using the methods which are independent of chemical additives application. To this end, physical, biological treatments and their combinations are included in this section.

2.2.1. Physical treatments

So far some single physical treatments such as sonochemical irradiation, electrical flow, or a combination of different physical treatments have been applied for the decontamination of effluents from various origins. However, the number of literature publications on the single physical treatments of PPME is relatively rare. With the aim of reducing colour and turbidity, Shaw and Lee carried out an ultrasonic treatment (at 357 kHz) of effluents from Kraft P&P mill. It was observed that the irradiation of ultrasound for 25 h resulted in the drop in the absorbance of the spectra above 250 nm for aromatic compounds. Ultrasound irradiation (20 kHz–10 MHz) can cause the cavitation involving the formation, growth, and instantaneous implosive collapse of bubbles in the liquid. This process generates local hot spots with high temperatures (up to 5000 °C) and pressures exceeding 500 atm together with shock wave and microjet (400 km/h). Under these conditions, the destruction of the aromatic compounds in the content of the effluent is facilitated. The simultaneous removal of colour and COD by using physical methods has been reported by Ebrahimi et al. They developed a multi-stage ceramic membrane system consisting of a microfilter, an ultrafilter and a nanofilter to diminish COD and residual ligninfrom alkaline bleaching effluent of a P&P industry (Fig. 2). Such a combination can act as an energy-saving and environmentally friendly method for the removal of contaminants and organic matters from PPME as aimed by some other related studies. According to the results obtained by Ebrahimi et al., the sequential two-stage process using microfilter and ultrafilter resulted in a good performance in terms of COD and residual lignin removal by 45% and 73%, respectively.

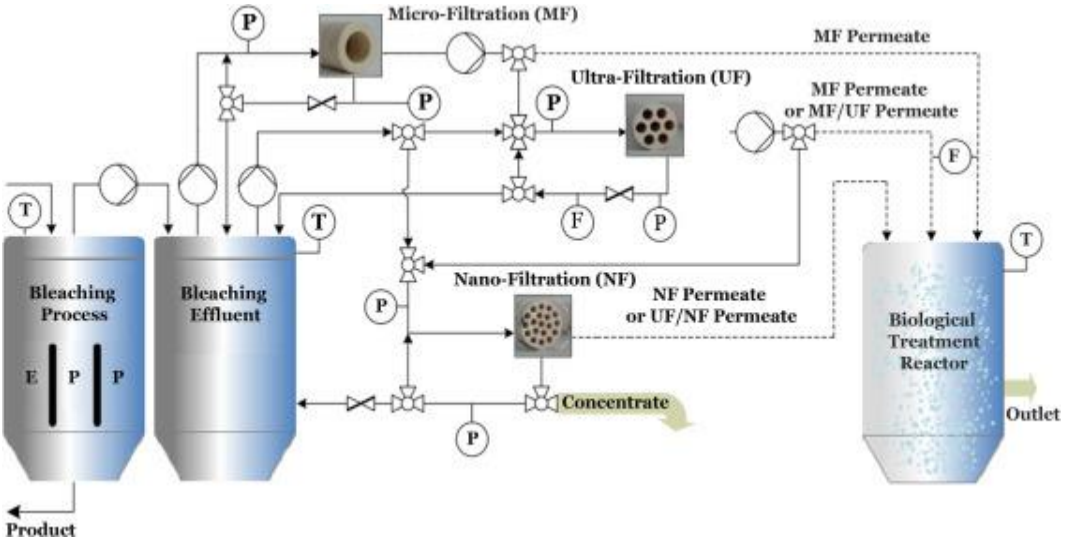

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Fig. 2. A schematic of a multi stage filtration process for the treatment of bleaching effluents, adapted from Ebrahimi et al.

2.2.2. Biological treatment methods

Biological treatment methods, which rely on the activity of various strains of microorganisms to break down organic substances and harmful compounds, seem to be economically and environmentally superior to most physical and chemical methods applied for the treatment of different types of effluents, including PPMW. The main problem with the application of biological treatments has been the incomplete treatment of the stream, especially in the case of the presence of recalcitrant pollutants such as AOXs in bleaching effluents and lignin-derivatives in the liquor. However, some efforts have been very recently applied to reinforce the bacterial activities to remove such complex compounds. Hooda et al., employed a rod-shaped Gram-positive bacterial strain RJH-1 (isolated from sludge) for the treatment of pulp and paper mill effluents. Although during initial 24 h of experiments, no significant changes happened to COD and colour, probably due to the slow adaptation of the bacteria to wastewater conditions, after a 5 days batch experiments 69% COD, 47% colour and 37% lignin removals were observed. It is worthy to note that microbial

strain was also capable to reduce AOXs by 39%. Other microbial strains have been also recently extracted from other media and applied for the P&P mill effluents treatment. Tyagi et al. isolated two dominant bacteria *Bacillus* subtilis and *Micrococcus luteus*, as well as one fungi *Phanerochaete* crysosporium from the soils polluted with P&P mill effluent. They applied microbial stains for the treatment of the effluents from a pulp and paper industry and achieved a lignin removal of 97% after 9 days. In this period, the consortium was also capable to remove 87.2% and 94.7% of BOD and COD, respectively. Similar removals of BOD and COD by other bacterial consortiums have also been recently observed. Significant removals of BOD, COD, and total solids (TS) of 81.25%, 53.23%, and 81.19%, respectively, were achieved by Nadaf and Ghosh by utilization of a non-sporulating bacteria, namely *Rhodococcus sp*. NCIM 2891 for the degradation and detoxification of PPMW. Likewise, the concentration of heavy metals recorded from the biologically treated effluent was less compared to that of influents. Besides the bacterial consortiums, some algal communities have also shown a good performance for removing the organic material, toxic compounds, and nutrients from PPMW in a cost-effective manner. For example, Usha et al. reported removal efficiencies of 82%, 75%, 65% and 71.29% for BOD, COD, NO_3-N and PO_4-P, respectively, from PPMW using a mixed culture of microalgae in an outdoor open pond.

Natural-like systems such as constructed wetlands (CWs) have also recently attracted a significant interest as promising biological options to diminish the nutrients and the pollutants from wastewaters. The main advantages of such systems are their cost-effectiveness and less environmental impacts as compared to conventional treatment approaches. Choudhary et al. studied the performance of horizontal subsurface flow (HSSF) constructed wetland planted with *Canna indica* for the removal of pollutants from PPMW. At an HRT of 5.9 days, the average percentage removals of 89.1% and 67–100% were achieved for AOX

and chlorophenolics, respectively, from PPMW. Moreover, Arivoli et al. evaluated the efficiency of vertical flow constructed wetlands by using three common aquatic macrophytes (i.e. *Typha angustifolia*, *Phragmites australis* and *Erianthus* arundinaceus) for the removal of heavy metals from P&P mill effluent. The results showed average removals of 74%, 80%, 60%, 70%, 71%, and 70% for iron, copper, manganese, zinc, nickel, and cadmium, respectively. Furthermore, among the three species of macrophytes used in CWs, *E. arundinaceus* showed the best performance.

Anaerobic digestion (AD) processes with different levels of performance have been also reported in the literature for the bio-treatment of P&P mill effluents. Nevertheless, among the various kinds of effluent streams generated from P&P mills, the full-scale AD has been only performed successfully for effluents from the bleached/unbleached thermo-mechanical pulp (TMP) and chemical thermo-mechanical pulp (CTMP) as well as neutral sulfite semi-chemical (NSSC) and Kraft/sulfite mill condensates. It is worth noting that despite AD has numerous advantages, especially low excess solid wastes produced and energy recovery in the form of biogas, the existence of some obstacles has restricted the full-scale applications of AD in the P&P mills. These barriers are mainly related with the innate hardness in associated to the digestion of non-biodegradable compounds such as lignocellulosic material and also facing with a diversity of inhibitors (e.g., sulfur, resin acids, ammonia, heavy metals, and organochlorine compounds) as well as the necessity of adjusting specific operational conditions and the need for adopting proper reactor configuration for anaerobic degradation optimization. Very recent studies have been mainly focused on overcoming these obstacles and optimizing the AD performance for complying with the stringent environmental standards and achieving economic benefits. In an effort, Steffen et al. studied an anaerobic digestion experiment for evaluating the biochemical methane potential (BMP) of separating fines from industrial recycled fiber pulp (RFP). In order to obtain a better understanding, convention-

al chemical and mechanical pulps were used as benchmarks for methane production. While methane yields of fines from mechanical pulps and RFP were measured as 21–28 mL/g_{VS} and 127 mL/$g_{VS,}$ respectively, a highest methane yield (375 mL/g_{VS}) was attained for fines fractions from chemical pulps owing to the fact that refining chemical pulp increases the fibers' bonding surface area, thereby causing greater access of microorganisms to the fibers and increasing rate of biodegradation. On the contrary, a large amount of lignin in the fines fractions from mechanical pulps, in addition to a high content of inorganic fine particles ($CaCO_3$) and the greater hydrolysis residue regarding the separated fines from RFP might be the reasons for lower gas production. The results suggested that the fines fractions from RFP are appropriate for biogas production even though the obtained biogas yields were merely one-third as compared to the ones obtained with chemical pulp fines.

Amongst the various types of anaerobic reactors, upflow anaerobic sludge blanket (UASB) has retained a special place in the P&P industry over the past few years. Indeed the main reasons for adopting this type of reactor are related to its profitability in terms of high organic loading rate (OLR) capacity, together with the low operation expense, and the production of rich methane biogas as by-product.

When focusing on the anaerobic treatment of especial P&P mill effluents, some opportunities for further studies are still identified. For instance, very few studies have been carried out so far on the treatment of bagasse effluents from P&P industry especially by conventional AD reactors such as UASBs. Furthermore, no model has been developed to predict the COD removal percentage, COD removal rate, and biogas production from the mentioned effluents. Sridhar et al. studied the anaerobic digestion of bagasse effluents from P&P industry to explore the interactive effects of influent chemical oxygen demand (COD_{in}), hydraulic retention time (HRT), and temperature on the performance of a continuous UASB reactor. In their work, the Box-Behnken design was applied for anal-

ysis and modeling the interactive effects of the three variables (COD_{in}, HRT, and temperature) on the responses. Based on the obtained results, under optimum conditions (COD_{in}: 6212 mg/L, HRT: 23 h, and temperature: 35 °C), the highest values of COD removal percentage (84.3%), COD removal rate (230.9 mg/L h), and biogas production (21.2 l/d) were achieved.

Operating a UASB reactor for anaerobic treatment of a bleaching stream can lead to more satisfactory results than the total effluents generated from a P&P mill; as bleaching streams typically contain a higher concentration of organic substances or, in other words lower volumes of water need to be treated to achieve the same results. Larsson et al. investigated the performance of two lab-scale UASB reactors working in *meso*philic condition on the treatment of two types of alkaline kraft elemental chlorine-free bleaching wastewaters (hardwood and softwood). The results showed the filtered total organic carbon (fTOC) reduction of 43% and 60% as well as the biogas production of 120 NmL g TOC_{IN}^{-1} and 250 NmL g TOC_{IN}^{-1} for softwood (SW) and hardwood (HW) wastewaters, respectively. The methane content of the produced biogas was 75% for both reactors. Based on the results achieved, UASB application can be considered as an appropriate technique for anaerobic digestion of alkaline bleaching effluents produced in kraft PPMs.

Development of novel and advanced types of anaerobic reactors has also been a topic of high interest in recent studies. Some types of AD reactors such as static granular bed reactor (SGBR) without the need for mixing, and aiming to save energy, have been a subject of interest, but still at a lab-scale application. Turkdogan et al. compared the performance of a SGBR with a UASB reactor for the treatment of thermo-mechanical paper mill wastewater in a laboratory-scale experiment. This study was performed within 110 days with hydraulic retention times (HRTs) of 4, 6, 9 and 24 h. The results indicated that in both reactor systems the COD removal efficiency was improved with the increase in HRT, ranging from 67% to 92% for SGBR and 60–90% for the UASB reactor. Thus,

SGBR exhibited not only exhibited approximately identical ability as UASB for the removal of organics from P&P mill wastewater, but was also slightly better than the UASB in terms of operational difficulties. So, SGBR system would be a proper alternative as conventional reactors for the anaerobic digestion of P&P mill effluents. Another type of anaerobic reactor applied to the treatment of P&P mills wastewater is the moving bed biofilm reactor (MBBR) which can result in an acceptable removal of organic matter and also in the biosynthesis of added-value products. For example, Baeza et al. treated a real PPMW by MBBR, aiming to evaluate the effect of different operational parameters (i.e. BOD_5/nitrogen (N)/phosphorus (P) ratio) on the Polyhydroxyalkanoate (PHA) biosynthesis rate during two experimental phases. In phase I, the best results for the accumulation of PHA (85.10%) and removal of organic matter (95.60%) were obtained using a BOD_5/N/P ratio of 100:5:1. However, for phase II, the highest PHA percentage (89.41%) and organic removal (97.10%) were achieved with BOD_5/N/P ratios of 100:1:0.3 and 100:5:1, respectively. The results achieve can emphasize the efficiency of the membrane bioreactors to deal with highly polluted effluents.

Sequencing batch reactors (SBRs) are also among the suitable biological systems for the treatment of wastewaters such as PPME, due to their design simplicity and functional flexibility. Muhamad et al. treated a real recycled paper mill effluent using three forms of lab-scale aerobic bioreactors, containing two attached-growth SBR (AG-SBR) systems with or without additional biomass, and a suspended growth SBR (SG-SBR). Over a 300-days observation period, the attached-growth SBR with additional biomass showed the best operational stability and average removal performance of 95%, 82%, 95%, 92%, 86%, and 60% for the relevant parameters, namely COD, colour, turbidity, SS, NH_3-N, and PO43-P, respectively.

The manipulation of anaerobic digestion reactors can also enhance biogas production and treatment efficiency for a given industrial effluent. The main

problem here is that in some cases, the effluents have high COD (e.g., in case of black liquor) or high concentrations of toxic materials (e.g., AOXs). As a promising strategy, co-treatment approach can encompass many potential benefits including dilution of inhibitory and toxic compounds, establishing a balance between nutrients as well as increasing the diversity and synergistic effect of microorganisms in the system. Also, economic benefits may be obtained from equipment sharing. However, despite the numerous advantages of co-treatment strategies, nowadays very few facilities have been adopted for the process due to some concerns such as the need for upgrading or strengthening the existing facilities, process instability, unsuccessful operation arising from undesirable suspended impurities, and digester overloading which can lead to foaming problems and unexpected failure of the process. According to the above shortcomings, so far only few studies have been conducted on the use of co-treatments in P&P industry. Most of the published work have concentrated their attention on the combination of P&P primary and secondary sludge with substrates such as food waste, municipal sewage sludge and monosodium glutamate waste liquor. Co-treatment with microalga is another candidate to enhance the overall performance of the anaerobic digestion process. Gentili mixed the effluents from municipal and industrial sources. Afterwards, three microalgal strains (Scenedesmus dimorphus, *Selenastrum minutum* and *Scenedesmussp*.) were grown in three wastewater mixtures (P&P influent 4:1 dairysludge; P&P influent 1:1 municipal influent; P&P influent 2:1 dairy final effluent), named as a, b and c wastewaters, respectively. Based on the results, the highest lipids yield, up to 37% of the dry matter was obtained in the wastewater mixture (a) by *Selenastrum minutum*. In addition, the highest COD removal (92.7%) was attained in the wastewater mixture (a) with the *Scenedesmus sp*. Therefore, mixing the P&P wastewater with dairy and municipal wastewaters was found effective not only in wastewater treatment but also for the production of biomass with high amounts of lipids.

Photofermentation process, as one of the most desirable biological approaches for biohydrogen production from organic substrates, is another option to deal with P&P mill effluents. However, the practical applicability of this approach for lignocellulosic-based wastewaters, such as PPMW, has been restricted with a degradation deficiency and low hydrogen yield due to their complicated and resistant structure to microbial enzymatic attacks. Budiman et al. investigated the potential of co-treatment approach by combining palm oil mill wastewater (POMW) and P&P mill effluent for bacterial growth and biohydrogen production using photofermentation. The results revealed that with a mixture of wastewater containing 25% (v/v) POME and 75% (v/v) PPME the maximum biohydrogen yield of 4.670 mL H_2/mL can be achieved. Moreover, in this study the highest COD_{total} removal (up to 28.8%) was observed during 72 h of photofermentation using *R. sphaeroides* NCIMB8253. Thus, co-treatment of POME with PPME was found to be effective for reducing turbidity as well as for improving the visibility of wastewaters during photofermentation process. Furthermore, by mixing a proper ratio (9:1) of PPME and brewery wastewater (BW), Hay et al., achieved a biohydrogen yield of 0.69 mol H_2/L_{medium} from photofermentation process. This combination also led to SCOD removal, soluble carbohydrate consumption, and light efficiency of 36.7%, 32.1%, and 1.97%, respectively.

2.2.3. Combined physico-biological treatment methods

Due to the insufficient treatment output of the single treatment methods, various studies have claimed the necessity of combining biological and physicochemical methods. Considering the benefits of such combinations, either in terms of economical-environmental aspects as well as the potential synergistic effects, Mishra et al. studied the efficiency of an integrated system including upflow fixed-bed anaerobic bioreactor (UFBAB) and slow sand filter (SSF) for the removal of pollutants from PPMW (Fig. 3) as compared to a single UFBAB. At different HRTs, the hybrid system showed a very high removal efficiency of

90%, 99%, 100%, and 100% for BOD, COD and total dissolved solids and total suspended solids, respectively. Similarly, in the case of sulfate and phenols removal, a relative high efficiency was attained, indicating a very good performance for such combined system.

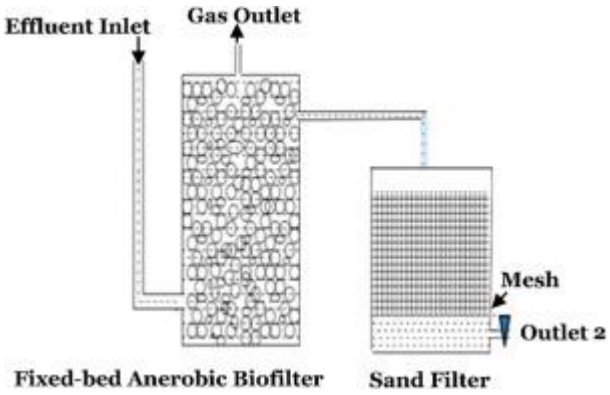

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Fig. 3. A scheme of a biofilter designed for P&P mill effluent treatment, adopted from Mishra et al.

Recent studies have also demonstrated that pre-treatment of lignocellulosic materials by moderate ultrasound irradiation could break down their complex composition via the development and collapse of cavitation bubbles, which can lead to a positive effect on the biohydrogen production from the fermentation process. In this regard, Hay et al. investigated the effects of ultrasonic power (30–90%) and duration (15–60 min) on the photofermentation process of PPMW. Based on the results obtained, the biohydrogen yield of all PPMWs pretreated by ultrasonication was higher than the ones obtained with the raw substrate, ranging between 0.041 and 0.077 mL H_2/mL. The maximum cumulative biohydrogen production (430%) and SCOD removal efficiency (25.9%) were achieved at the amplitude of 60% and time of 45 min (A60:T45), respectively. Moreover, economic assessment conducted in this research showed that ultrasonic pretreatment prior to biofermentation of PPMW could have a positive net saving in comparison with raw PPMW, due to the higher incomes from selling the biohydrogen and further reduction in costs related to the COD removal.

Once more, Hay et al. applied various ultrasound irradiation times (5, 10 and 15 min) and amplitudes (15%, 30%, and 45%) to specify the optimal ultrasonication conditions for pretreatment of *Rhodobacter sphaeroides*. As indicated in Fig. 4 (a) moderate ultrasonic pretreatment could stimulate the generation of pores in the cell membrane of *R. sphaeroides* or slightly disrupt surface of cell, whilst higher-frequency ultrasonic was able to create more pores in cell surface, thereby resulting in further change of the cell morphology as compared to the untreated bacteria cell. Thus, highest hydrogen yield (9.62 mL bioH_2/mL) was attained at A30:T10 due to the fact that moderate ultrasonic applied to *R. sphaeroides* could improve the enzymatic activities of the cell with modification of membrane permeability and resistance, leading to increase degradation of large-size molecules into smaller ones. However, the higher release of intracellular products in the ultrasonic-pretreated PPMW caused a lower SCOD removal efficiency after biohydrogen production process as compared to the control substrate.

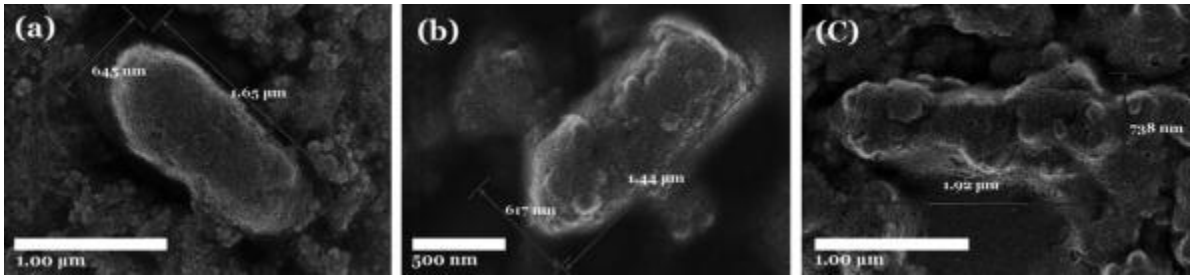

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Fig. 4. FE-SEM images of R. sphaeroides NCIMB8253 after undergoing (a) no ultrasonication; (b) ultrasonication with amplitude 30% and 10 min; (c) ultrasonication with amplitude 45% and 15 min, adopted from Hay et al.

In another effort to improve the biohydrogen production, Budiman and Wu evaluated the performance of ultrasound pretreatment (amplitudes of 30–90% and duration of 5–60 min) on a combined substrate consisting of PPMW and POME. The maximum hydrogen production rate (8.72 mL H_2/mL_{medium}) and COD removal efficiency (36.9%) were achieved by using A70:T45 ultrasoni-

cation. The improvement of biohydrogen production was linked to the positive effect of ultrasound irradiation on the release of lignin and cellulose from the structure of substrates, leading to increased bioavailable nutrients which could be simply degraded by fermentation bacteria.

2.3. Combined additive and non-additive treatment methods

2.3.1. Physico-chemical combined treatment methods

Application of various physical stimulates such as vibration, electricity flow, temperature, photo irradiation, filtration, and pressure, etc. can potentially enhance the performance of methods based on the addition of chemicals for the treatment of industrial effluents. For instance, the combination of ultrasonic irradiation with AOPs can be an interesting solution for the removal of recalcitrant pollutants from P&P mill effluents. Generation of powerful hydroxyl groups as a result of ultrasonic irradiation can facilitate the oxidation of complex organic materials especially when combined with methods such as Fenton-like oxidation treatments. Eskelinen et al. studied the treatment of bleaching effluents from a P&P mill using a combination of ultrasonic irradiation in combination with Fenton-like oxidation (Fe^{3+}/H_2O_2) or photo-Fenton degradation ($Fe^{2+}/H_2O_2/UV$). Such an integration resulted in COD removals of 12%, 20%, and 28% from effluents by using Fenton-like oxidation, photo-Fenton's oxidation or electro-oxidation treatment, respectively, at the reaction conditions of dose of Fe(III)-1 g/L; dose of H_2O_2-3 g/L, pH-6.9, agitation speed: 200 rpm, and contact time-60 min. It has been also reported that ultrasonic irradiation can facilitate the coagulation process especially when combined with electricity. Asaithambi et al. showed that the application of sono-electrocoagulation can yield 95% and 100%, for the removal of COD and colour, respectively, at a current density of 4 A/dm^2, electrolyte concentration of 4 g/L, initial pH of 7, COD concentration of 3000 mg/L, electrode combination of Fe/Fe, inter-electrode distance of 1 cm, and reaction time of 4 h. Although filtration is not able to treat highly polluted industrial effluents, as in the case of PPMW, its

combination with methods based on the addition of chemical additives can be considered as a good candidate to promote the overall efficiency of wastewater treatment plants. For instance, Gholami et al. applied a hybrid system assembled with ultrafiltration (UF) membrane and AOPs in order to treat an effluent from fiber sewer collection unit. They indicated that the UF permeate quality was not sufficient to satisfy the related environmental regulations. As the next step, they applied AOPs under which sulfate and hydroxyl radicals were generated through the activation of persulfate ($S2O82-$) and H_2O_2 by Fe(II) to deal with the pollutants. Under optimized operational conditions, ($[H_2O_2] = 15$ mM, [Fe (II)] = 6 mM, and pH = 3), the removal efficiency of COD, UV_{254}, and UV_{280} were 95.02%, 86.74% and 87.08%, respectively. Additionally, in order to reduce the reaction time and costs, Salazar et al. combined AO-H_2O_2 with UF, nanofiltration (NF) and reverse osmosis (RO) treatments. The results for TOC removal by integrated filtration/AO-H_2O_2 indicated that the best pair-treatments for acid and alkaline bleaching effluents were UF/AO-H_2O_2 (68% of TOC removal) and NF/AO-H_2O_2(96% of TOC removal), respectively. AOPs can also compensate the deficiency of electro-coagulation for the complete treatment of PPMW. Jaafarzadeh et al. mixed electro-coagulation with UV oxidation for the removal of organic compounds from a P&P mill wastewater (COD = 1537 mg/L). Under optimum conditions (natural pH, time = 33.7 min and current density = 5.55 mA/cm^2) they achieved 61% of the COD removal. In a recent study, Abedinzadeh, Shariat and Masoud applied an SBR method in combination with AOPs for the treatment of P&P wastewaters. Using a response surface methodology (RSM), they achieved an optimum COD and colour removals of 98% and 94%, respectively, under $Fe^{2+}$and H_2O_2 dosages of 3 mM and 9 mM, respectively at pH of 3.0 and 30 min.

For a sustainable treatment of industrial effluents, there is also a need for cheap and environmentally friendly additives. So far, some attempts have been made in this regard. As shown by Zhuang et al., who used waste rice straw and

iron-containing sludge to prepare catalytic particle electrodes. Electro-Fenton (EF) oxidation applied to real paper mill wastewater using the prepared electrodes under optimized treatment conditions (current density of 10 mA/cm^2, a catalytic particle electrodes dosage of 1.0 g/L, and an aeration rate of 5 L/min) reached allowed 86% of SCOD removal.

Due to the fact that sun is a renewable energy source that is free but dependent on the season and geographical conditions, it can be used as a source of light for treatment processes. It can also be combined with other physico-chemical methods to enhance the overall treatment efficiency. As a good example, a multi-barrier treatment (MBT) comprising the steps of filtration, photolysis of hydrogen peroxide (H_2O_2/UVC) and catalytic wet peroxide oxidation (CWPO) using granular activated carbon (GAC) as catalyst demonstrate a remarkable efficiency for synthetic industrial effluents post-treatment, particularly because of the possibility of removing residual H_2O_2 and some by-products generated during H_2O_2/UVC process through subsequent filtration by GAC column. Accordingly, Rueda-Márquez et al. investigated the viability of a MBT process for post-treatment of plywood mill effluent on a pilot scale. As a result, over the MBT process, the concentration of COD and TOC decreased by 88.5% and 76%, respectively, while SS and turbidity decreased by 89% and 70%, respectively. Moreover, an almost complete H_2O_2 removal (95%) was achieved after CWPO process (1.5 min of contact with GAC). On the other hand, the operation and maintenance cost for this MBT process was estimated as 0.95 €/m^3

2.3.2. Bio-chemical combined treatment methods

Former studies have clearly indicated that the application of either a single biological or a single chemical method would not be enough to complete treatment of the P&P mill effluents in order to satisfy legal requirements and protect the environment. Besides some species of single bacteria, mixed culture acclimated biomass as well as biofilms can partially or completely degrade adsorba-

ble organic halides (AOX). Considering the fact that AOX has a severe toxic effect on the growth of microorganisms, combining two process; adsorption and biofilms, more satisfactory results can be achieved for AOX treatment. On the other hand, HRT is one of the most important parameters that should be considered for achieving optimal conditions for wastewater treatment. Osman et al. by combining adsorption and biological processes at a lab-scale granular activated carbon sequencing batch biofilm reactor (GAC-SBBR) under aerobic conditions, tried to evaluate the effect of HRT on the GSC-SBBR performance in terms of the simultaneous removal of AOX and COD from a recycled paper mill wastewater. For this purpose, the reactor was packed with 80 pieces of cylindrically shaped plastic media with GAC of sizes in the range of 6–8 mm. These packing materials played two roles, both as adsorption medium and as a medium for biofilm growth. The results indicated that just a meagre efficiency can be achieved in the COD removal when HRT reduces from 48 h to 8 h. The results also demonstrated that the treatment efficiency for the reduction of COD and AOX from P&P mill effluents with GAC-SBBR can be obtained were as high as 92% and 99%, respectively, at an HRT of 48 h.

Addition of trace elements to the biological treatment systems has also been a solution to enhance the efficiency of the treatment, especially when facing with a highly polluted and complex effluent, as also previously observed for other types of industrial effluents. This idea was tested by Barnett et al. to promote the effluents from a TMP process by adding trace metals including Ca, Co, Cu, Fe(III), and Mg to an activated sludge (AS) plant as one of the common biological treatment to deal with P&P mill effluents. They indicated that such trace elements are capable to enhance the COD removal from 82% to 86% (1.0 mg/L).

3. Challenges and opportunities

Currently, P&P mills continue to seek sustainable management solutions to overcome their difficulties in production processes

and also to deal with economic and environmental management issues. It is also of high importance for a good solution to establish a logic connection between the process engineering and economic considerations in line with the adoption of the best suited treatment process. Several techno-economic analysis have been carried out recently in order to optimize the production processes to have less environmental drawbacks while providing more quality for the products in an economic perspective. But, industry is not yet able enough to minimize the pollution load in final effluents and it is expected for effluents from P&P industry to remain as one of the most polluted industrial wastewaters through the world containing recalcitrant and complex organic compounds. There are a number of evidence for the soil pollution of the pulp and paper mills surrounding environment and severe toxic effects for the local biotic communities if discharging their wastewaters without efficient treatment. In this situation, the end of pipe treatment of the wastewater will be considered, at least in the forthcoming years, as the main way to satisfy environmental protection communities. The stages involved in the treatment of such highly polluted and complex effluents are currently subjects of negotiations among the scientific communities. Some studies emphasizes that a series of biological treatments are good candidates to achieve the treatment goals regarding the stringent environmental protection standards and regulations. For instance, Buyukkamaci and Koken in the year of 2010 by comparing ninety-six treatment plants (in Turkey) having a single physical treatment, chemical treatment, aerobic and anaerobic biological processes or their combinations according to economic criteria including investment, operation, maintenance and rehabilitation costs tried to suggest an optimum treatment method for the P&P industry. They concluded that an extended aeration activated sludge process is the best option for low strength effluents, while extended aeration activated sludge process or UASB followed by an aeration basin can act efficiently for medium strength effluents, and finally UASB followed by an aeration basin or UASB followed by a con-

ventional activated sludge process can optimize the techno-economic considerations for the treatment of high strength P&P effluents. However, the necessity of allocating a relatively large area for biological treatments, relatively long-time treatment requirements as well as uncompleted treatment and local issues such as the bad smell resulting from the bacterial activities are the main drawbacks of such systems. In addition, conventional biological treatments have shown a limited efficiency for the treatment of recalcitrant and complex pollutants such as AOXs which can remain in the treated effluents, causing several environmental and health problems. Hence, there is also a need to perform further life cycle assessment studies for the biological treatment methods applied to this type of effluents. The scientific orientation observed by the researchers in very recent literature emphasizes that the emerging novel technologies could considerably eclipse the idea of using sequential biological treatments. Economic analysis performed in some physico-chemical treatments methods, such as Fenton process, indicated their cost-effectiveness. In addition, with respect to adsorption processes it has been reported in the literature that activated carbons, among the existing adsorbents, can offer a high adsorption performance due to its specific characteristics such as large surface area and pore volume, high-speed kinetics and coarse texture. However, although in comparison with relatively expensive adsorbents such as silica, activated carbon can contribute to minimize the overall treatment cost, it may be here suggested the need to develop the application of cheap materials that are by-products of other natural or artificial chemical-based processes as adsorbents. Hence, it is also recommend wider applications of biochar not only because of its low cost and high performance but also due to its potential to reduce toxicity to the environment (such as soil) after the treatment process. In this regard, ashes can also be a good candidate to this end, containing relatively high amounts of metallic elements such as Fe, Ca, Na, etc. Besides their ability to adsorb contaminants from the polluted effluents, they readily release relevant cations to the media. This can promote the treatment efficien-

cy via inducing chemical reactions with the release of electrons from the metallic elements in the media such as those (such as iron ions) used for the removal of toxic materials from the effluents such as nitrate. They can also provide enough nutrients in the final sludge content, making them suitable for land-use utilizations, for instance for agricultural applications which may need a sludge with a minimum content of toxic substances and enough amounts of nutrient elements. The wastes from wastewaters treatment plants (such as secondary sludge) can also be considered as a low cost solution to adsorb recalcitrant compounds. However, the final sludge after the adsorption process can be harmful to the environment due to the attachment of toxic compounds to its surface. In this case, probably the incineration is the only existing way to deal with the final wastes, which will cause some environmental drawbacks. In the other hand, some novel technologies such as the application of mesoporous nanomaterials with high adsorption capacity can also make a revolution in the treatment of highly polluted and complex effluents from pulp and paper industry. In this regard, enough engineering efforts must be done to maximize the efficiency of such materials for better treatment results. This can be achieved by adopting optimization techniques such as surface response methodology to reach best results in a cost-effective manner. Such efforts can also be made for the synthesis of materials with high optical properties to reduce the need for irradiation of light to the reaction medium during the processes such as oxidation of effluents. In this way, economic considerations of the treatment process can be also satisfied.

The combination of various additives can also result in the promotion of the treatment efficiency. Also, the combination of various additive-based methods with biological methods have shown attractive results for the elimination of recalcitrant pollutants from P&P mill effluents such as AOXs and to promote the overall efficiency of COD and BOD removals, which can result in a better quality for the final effluents. There is also a need to design combined reactors to join

physico-chemical and biological methods by taking into consideration that such systems must not only enhance the overall treatment performance, but also be technically and economically feasible enough to encourage investors. This latter item is currently the main obstacle for the rapid commercialization of the lab-scale developed novel methods, especially in developing countries.

Application of chemical additives can generally raise some concerns on their toxic effects when released to environment. Furthermore, the review of recent studies on the treatment of P&P mill effluents reveals a trend for the use of chemical additives but without enough eco-toxicological studies. This issue is of high importance because recently the concern on the effects of the remaining toxic chemicals after the treatment process has increased considerably in the scientific community. Hence, there is an urgent need to carry out life cycle assessment studies for emerging additive-based technologies for the treatment of highly polluted and complex industrial effluents such as those released to environment from the P&P industry.

It is also worthy to mention that the selection of a sustainable method to deal with effluents from pulp and paper industry is a complex task, requiring the consideration of various technical, environmental and economic as well as social criteria. Hence, application of multi-criteria decision making systems (MCDM) is highly recommended in this regard to find the best available technologies for the treatment of pulp and paper mill effluents.

4. Conclusion

This paper presents very recent results achieved on the treatment of pulp and paper mill effluents based on the application of chemical additives alone or in combination with other physical or biological treatment methods. Moreover, recent developments on single biological and physical treatments or their hybrid application have been critically reviewed. As a result the interest of the scientific community to promote additive-based treatment methods in combination with conventional or novel physical or biological treatment methods could be high-

lighted. The overall trend in this field, as realized by the authors, is to promote techno-economic benefits of treatment processes. Furthermore, taking into account toxicology and environmental safety issues this review calls for joint studies or complementary studies on the subsequent environmental impacts of the novel combined technologies towards an efficient treatment method.
(https://doi.org/10.1016/j.wri.2019.100109)

Task 3. Summarize all the ideas of the article and write an essay.

Task 4. Make a presentation based on the article.

Часть IV. БЕСЕДА ПО СПЕЦИАЛЬНОСТИ

SUMMARY

Task 1. Read the following instructions offered by Virginia Kearney, a university expert in writing essays (https://owlcation.com/academia/How-to-Write-a-Summary-Analysis-and-Response-Essay, 05.2019).

A summary is telling the main ideas of the article in your own words.

Steps in Writing

These are the steps to writing a great summary:

1. Read the article, one paragraph at a time.
2. For each paragraph, underline the main idea sentence (topic sentence). If you can't underline the book, write that sentence on your computer or a piece of paper.
3. When you finish the article, read all the underlined sentences.
4. In your own words, write down one sentence that conveys the main idea. Start the sentence using the name of the author and title of the article (see format below).
5. Continue writing your summary by writing the other underlined sentences in your own words. Remember that you need to change both the words of the sentence and the word order.
6. Don't forget to use transition words to link your sentences together. See my list of transition words below to help you write your summary more effectively and make it more interesting to read.
7. Make sure you include the name of the author and article and use "author tags" (see list below) to let the reader know you are talking about what the author said and not your own ideas.

8. Re-read your piece. Does it flow well? Are there too many details? Not enough? Your summary should be as short and concise as possible.

Sample Format

Author Tag: You need to start your summary by telling the name of the article and the author. Here are three examples of how to do that (pay close attention to the punctuation):

1. *In "How the Civil War Began," historian John Jones explains...*
2. *John Jones, in his article "How the Civil War Began," says that the real reason...*
3. *"How the Civil War Began," by historian John Jones, describes....*

First Sentence: Along with including the article's title and author's name, the first sentence should be the main point of the article. It should answer the question: What is this essay about? (thesis).

Example:

In "How the Civil War Began" by John Jones, the author argues that the real reason for the start of the Civil War was not slavery, as many believe, but was instead the clash of cultures and greed for cash.

Rest of Summary: The rest of your essay is going to give the reasons and evidence for that main statement. In other words, what is the main point the writer is trying to make and what are the supporting ideas he or she uses to prove it? Does the author bring up any opposing ideas, and if so, what does he or she do to refute them?

Here is a sample sort of sentence:

_____ is the issue addressed in "(article's title)" by (author's name). The thesis of this essay is _____ . The author's main claim is _____ and his/her sub claim is _____ . The author argues _____ . Other people argue _____ . The author refutes these ideas by saying _____ . His/her conclusion is _____ .

Author Tag List

Author's Name	Article	Words for "Said"	Adverbs to Use With "Said"
James Garcia	"whole title"	argues	carefully
Garcia	"first couple of words"	explains	clearly
the author	the article (book etc.)	describes	insightfully
the writer	Garcia's article	elucidates	respectfully
the historian (or other profes-sion)	the essay	complains	stingingly
essayist	the report	contends	shrewdly

Transition Words List

Contrast	Adding Ideas	Emphasis
Although	In addition	Especially
However	Furthermore	Usually
In contrast	Moreover	For the most part

Contrast	Adding Ideas	Emphasis
Nevertheless	In fact	Most importantly
On the contrary	Consequently	Unquestionably
Still	Again	Obviously

RESPONSE

Response answers: What do you think? Does this article persuade you?

How to Write

Generally, your response will be the end of your essay, but you may include your response throughout the paper as you select what to summarize and analyze. Your response will also be evident to the reader by the tone that you use and the words you select to talk about the article and writer. However, your response in the conclusion will be more direct and specific. It will use the information you have already provided in your summary and analysis to explain how you feel about this article. Most of the time, your response will fall into one of the following categories:

- You will agree with the author and back your agreement up with logic or personal experience.
- You will disagree with the author because of your experience or knowledge (although you may have sympathy with the author's position).
- You will agree with part of the author's points and disagree with others.
- You will agree or disagree with the author but feel that there is a more important or different point which needs to be discussed in addition to what is in the article.

How will this article fit into your own paper? How will you be able to use it?

Here are some questions you can answer to help you think about your response:

1. What is your personal reaction to the essay?
2. What common ground do you have with the author? How are your experiences the same or different from the author's and how has your experience influenced your view?
3. What in the essay is new to you? Do you know of any information the article left out that is relevant to the topic?
4. What in this essay made you re-think your own view?
5. What does this essay make you think about? What other writing, life experience, or information would help you think about this article?
6. What do you like or dislike about the essay and/or the ideas in the essay?
7. How much of your response is related to your personal experience? How much is related to your own worldview? How is this feeling related to the information you know?
8. How will this information be useful for you in writing your own essay? What position does this essay support? Or where might you use this article in your essay?

Sample Format

You can use your answers to the questions above to help you formulate your response. Here is a sample of how you can put this together into your own essay:

Before reading this article, my understanding of this topic was _____. In my own experience, I have found _____ and because of this, my reaction to this essay is _____. Interestingly, I have _____ as common ground with the author/audience. What was new to me is _____. This es-

say makes me think _____. I <u>like/dislike</u> _____ in the essay. I will use this article in my research essay for _____.

VOCABULARY

article – статья;

summary – краткое изложение, конспект;

rendering – реферирование;

uncommon – редкий;

finding – находка, открытие, полученные данные;

to pay attention – уделять/обращать внимание;

conclusion – умозаключение, вывод;

to highlight – выделять;

to comprehend – понимать, осмысливать;

rough draft – эскиз, набросок;

firm grasp – чёткое понимание;

assignment – предписание, инструкция, задание;

to explain – объяснять;

in plain language – простым языком;

referring to – ссылаясь на;

meaning – значение, смысл;

to convey – выражать, передавать (идею, смысл);

appropriate – подходящий, соответствующий;

to feature in – принимать участие;

concisely – кратко, сжато, лаконично, выразительно;

cut and paste – «вырезать и вставлять» (объёмно цитировать без ссылки на источник, компилировать);

jumble – куча; беспорядочно сваленные в кучу вещи;

borders on – граничить grade – оценка, отметка;

option – вариант, альтернатива; опция.

Task 2. Read and translate the text. Use its main ideas for rendering scientific articles:

How to write a Summary of a scientific article.

Summarizing or rendering of a scientific article demonstrates your understanding of the material and presents this information to an audience that may not have a science background. It is not uncommon for a scientific article to describe an experiment and discuss its findings. To write an effective summary, you must be able to focus on the main ideas of the article. This also helps to understand scientific research better.

Instructions:

1. Read the entire article. Pay attention to the experiment methods and the conclusions presented. Read the article more than once, if necessary.
2. Look up any words or methods you do not understand.
3. Go through the article, and highlight its main ideas. Make sure you understand the main points in each para graph. Take notes so you have a starting point for your summary.
4. Test your understanding of the artic le by asking yourself questions about it. Try explaining the concept of the article to a friend or family member in non-scientific language. Determine if you can clearly explain the article in a way that is easy to comprehend.
5. Start a rough draft of your summary, using the notes you've written. Review the article to ensure you have a firm grasp of the conclusion. Summarize the article's conclusion. Offer your own interpretation of the conclusion along with your opinion of the article's content.

Task 3. Look through the “George Mason University Recommendations” on the writing of a summary of a scientific article. Be ready to answer the questions:

This assignment is generally intended to help you learn to synthesize scientific materials and communicate the main points effectively, using plain language.

Start by making sure you understand the central points of what you read. Explain the article in plain language to someone else and answer questions without referring back to the article, to make sure you have grasped the essence of what you read. Dr. James Lawrey in the Biology Department uses this assignment to teach students to pick out the meaning of an article and convey the main points. The appropriate writing style for a summary of a scientific article is to use simple sentences that express one or two ideas. An example might be a story featured in the mainstream media that explains a recent scientific finding, bringing out the important aspects concisely and without too much scientific jargon.
Do not "cut and paste" from the article. When students do not really understand what they read, their writing is a jumble of statements nearly straight from the article, with no interpretation or synthesis of the article's findings. This strategy is common among students who wait until the last minute to complete assignments. Besides the fact that this practice borders on or actually is plagiarism, it shows that students do not understand what they are writing about, and their grades reflect this.

Task 4. Answer the questions:

1. Who is James Lawrey? 2. What should you do at first while writing a summary? 3. Does the author limit the number of times his students should read the scientific article they are to summarize? 4. When do students use “cut and paste” function while writing a summary? 5. How do you understand the term “plagiarism”?

Task 5. Retell the Instructions on writing a Summary of a scientific article.

Task 6. Read the definition of summarizing/rendering in Russian. Try to remember as many set phrases as possible. Use them in the rendering of scientific articles.

Реферирование научных статей на английском языке – важный навык, необходимый любому современному инженеру. Суть реферирования можно свести к анализу прочитанной англоязычной работы с выделением её главной идеи, описанием перечисленных автором фактов и доводов и подведением итогов.
С этой целью можно использовать ряд вводных языковых конструкций:

1. Название статьи, автор, стиль. The article I'm going to give a review of is taken from… – Статья, которую я сейчас хочу проанализировать из… The headline of the article is – Заголовок статьи… The author of the article is… – Автор статьи… It is written by – Она написана (кем)… The headline foreshadows… – Заголовок приоткрывает…

2. Тема. Логические части. The topic of the article is… – Тема статьи это… The key issue of the article is… – Ключевым вопросом в статье является… The article under discussion is devoted to the problem… – Обсуждаемая статья посвящена проблеме… The author in the article touches upon the problem of… – В статье автор затрагивает проблему…. I'd like to make some remarks concerning… – Я бы хотел(а) сделать несколько замечаний по поводу… I'd like to mention briefly that… – Хотелось бы кратко отметить, что… I'd like to comment on the problem of… – Я бы хотел(а) прокомментировать проблему… The article under discussion may be divided into several logically connected parts which are… – Статья может быть разделена на несколько логически взаимосвязанных частей, таких как…

3. Краткое содержание. At the beginning of the article its author… – В начале статьи автор… …describes – описывает …depicts – изображает …touches upon – затрагивает …explains – объясняет …introduces – знакомит …mentions – упоминает …makes a few critical remarks on – делает несколько критических замечаний о The article begins (opens) with a (the)… – Статья начинается… …description of – описанием …statement – заявлением …introduction of – представлением …the mention of – упоминанием …the analysis of / a summary of – кратким анализом …the characterization of – характеристикой …(author's) opinion of – мнением автора …the enumeration of – перечнем In conclusion the author – в заключение автор …dwells on – останавливается на …points out – указывает на то …generalizes – обобщает …reveals – показывает …exposes – показывает …accuses / blames – обвиняет …gives a summary of – дает обзор…

4. Отношение автора к отдельным моментам. The author gives full coverage to… – Автор полностью охватывает… The author outlines… – Автор описывает… The article contains the following facts…./ describes in details… – Статья содержит следующие факты …. / подробно описывает… The author starts with the statement of the problem and then logically passes over to its possible solutions. – Автор начинает с постановки задачи, а затем логически переходит к ее возможным решениям. The author asserts that… – Автор утверждает, что … The author resorts to … to underline… – Автор прибегает к …, чтобы подчеркнуть… Let me give an example… – Позвольте мне привести пример…

5. Вывод автора. In conclusion the author says / makes it clear that…/ gives a warning that… – В заключение автор говорит / проясняет, что… / предупреждает, что… At the end of the article author sums it all up by saying

… – В конце статьи автор подводит итог всего этого, говоря… The author concludes by saying that… / draws a conclusion that… / comes to the conclusion that… – В заключение автор говорит, что .. / делает вывод, что… / приходит к выводу, что…

6. Выразительные средства, используемые в статье. To emphasize … the author uses… – Чтобы акцентировать внимание … автор использует… To underline … the author uses… – Чтобы подчеркнуть … автор использует To stress… – Чтобы усилить/подчеркнуть… Balancing… – Балансируя…

7. Ваш вывод. Taking into consideration the fact that – Принимая во внимание тот факт, что The message of the article is that… /The main idea of the article is… – Основная идея статьи (послание автора)… In addition… / Furthermore… – Кроме того…
On the one hand…, but on the other hand… – С одной стороны …, но с другой стороны… Back to our main topic… – Возвращаясь к нашей основной теме… To come back to what I was saying… – Чтобы вернуться к тому, что я говорил(а)… In conclusion I'd like to… – В заключение я хотел(а) бы… From my point of view… – С моей точки зрения… As far as I am able to judge… – Насколько я могу судить… My own attitude to this article is… – Мое личное отношение к этой статье... I fully agree with… / I don't agree with… – Я полностью согласен / не согласен с… It is hard to predict the course of events in future, but there is some evidence of the improvement of this situation. – Трудно предсказать ход событий в будущем, но есть некоторые свидетельства улучшения ситуации. I have found the article dull / important / interesting /of great value – Я нахожу статью скучной / важной / интересной/ имеющей большое значение (ценность).

Task 7. RETELLING.

Read text of the article several times. Work in pairs or groups. Divide text into parts, so that each group will have at least several sentences. Select the key words in the texts, type them in Word it Out (https://worditout.com/) and generate a cloud. Retell the story with the help of the generated word clouds. If two words need to be together, imagine "suffer from", you only need to insert _ between the two words and they'll be kept together in the cloud.

Пример рассказа о научных интересах магистранта/аспиранта:

1. What is your name? - My name is Ivan Ivanovich Ivanov.

2. What educational institution did you graduate from? When? -I graduated from …in 20…

3. What is your speciality? -My speciality is …/ My profession is …

4. Why did you decide to take a post-graduate course? -I decided to take a post graduate-course because I had been interested in science since my 3-d year at the University / because scientific approach is very important in my profession.

5. What is the subject of your future scientific research? -The subject of my scientific research is … -My future scientific research is devoted to the problem of … - My future scientific research deals with the problem of …

6. Who is your scientific supervisor? -My scientific supervisor is Ivan Petrovich Petrov, Professor, Doctor of technical/ economic sciences, Head of the Chair of … / Head of the Department of … -He has got a lot of publications devoted to the problem of …

7. Have you ever participated in any scientific conferences? -Yes, I've participated in many conferences devoted to the most actual problems of economy/physics/geodesy/hydrology etc. -Not yet, but I hope, together with my su-

pervisor, I'll prepare some reports for scientific conferences/I'll take part in several conferences in the near future.

8. Do you have any publications? -Yes, I've got some publications connected with my research. - Not yet, but I hope, together with my supervisor, I'll prepare some publications, they will be devoted to my research.

9.What methods are you going to use in your investigation? -Together with my supervisor we are going to apply such methods as theoretical, experimental, practical and computational methods because they will help me to complete my research.

10. What will your scientific research give the world? In what way can your investigation/research be useful to … science?

-I think / I hope / I dare say that the problem of our scientific research is very urgent and our scientific research will be very useful for … / it will help people in the field of …

Сокращения, встречающиеся в текстах

сокращение	читается/означает	перевод
%	percent (per cent) [pə'sent]	процент
° C	degrees Centigrade	градус (Цельсия)
° F	degrees Fahrenheit	градус (Фаренгейта)
A. D.	of our era ['ıərə]	нашей эры
a. k. a.	also known as	также известный как
B. C.	before Christ [kraıst]	до нашей эры
Btu	British thermal unit	британская тепловая единица
Btu	British thermal unit	британская тепловая единица
e. g.	for example	например
etc.	[et'set(ə)rə]	и так далее
EU	European Union	Евросоюз
ft	foot (мн. число feet)	фут
hp	horse power	лошадиная сила
hr	hour	час
i. e.	that is	то есть
in	inch	дюйм
kJ/kg	kilojoule per kilogram	килоджоуль на килограмм
kw	kilowatt	киловатт
lb	pound	фунт
mm	millimeter	миллиметр
Mpa	megapascal	мегапаскаль
Mw	megawatt	мегаватт
MWt	megawatt	мегаватт

сокращение	**читается/означает**	**перевод**
MWth	megawatt thermal	мегаватт
o. d.	outer diameter	внешний диаметр
psi	pounds per square inch	фунтов на квадратный дюйм
psia	pounds per square inch absolute	фунтов на квадратный дюйм (абсолютное давление)
psig	pounds per square inch gauge	фунтов на квадратный дюйм (избыточное давление)

Температура читается:

25° C – twenty-five degrees Centigrade ['sentɪgreɪd] (по шкале Цельсия);

34° F – thirty-four degrees Fahrenheit ['færənhaɪt] (по шкале Фаренгейта).

Literature recommended:

1.	Кириллова В.В., Вихман Т.М.	Английский язык: учебно-методическое пособие по переводу научно-технической литературы для студентов и аспирантов технических, специальностей - 2-е издание./ГОУВПО СПбГТУРП. СПб., 2008.
2	Кириллова В.В., Лиоренцевич Т.В., Знаменская А.М.	Английский язык. Некоторые трудности перевода с английского языка на русский литературы по специальности «Охрана окружающей среды»: учебно-методическое пособие /ВШТЭ СПбГУПТД. – СПб., 2017.
3	Электронный словарь	www.multitran.ru
4.	Стронг А.В.	Новейший англо-русский, русско-английский словарь с транскрипцией в обеих частях [Электронный ресурс]/ Стронг А.В.— Электрон. текстовые данные.— М.: Аделант, 2015.— 800 с.— Режим доступа: http://www.iprbookshop.ru/44107.— ЭБС «IPRbooks».
5.	Raymond Murphy	English Grammar in Use. A self-study reference and practice book for intermediate students. England. Cambridge University Press, 2012.
6.	Мюллер В.К.	Новый англо-русский, русско-английский словарь [Электронный ресурс]/ Мюллер В.К.— Электрон. текстовые данные.— М.: Аделант, 2014.— 512 с. Режим доступа: http://www.iprbookshop.ru/44108. ЭБС «IPRbooks».

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